Digital Photogrammetric System

PHOTOMOD

Version 6.0

USER MANUAL

Processing of UAS data

RACURS

Table of Contents

1. About 3
1.1. Purpose of the document 3
1.2. Purpose and main definitions 3
1.3. Technical Support 3
2. Input and output data 4
2.1. Input data 4
2.2. Output data 5
3. Program installation 6
4. Start of work 6
5. Interface and its elements 6
5.1. Work area interface 6
5.2. Brief description of main menu 7
5.3. The main toolbar 8
5.4. The “Orientation” menu 10
5.5. The Block menu 11
5.6. The “Block editor” window 12
6. Workflow of UAS processing 14
7. Creating and choosing active profile 16
8. Project creation 17
9. Images block forming 19
9.1. Image prepearing 19
9.2. Adding images 20
10. Interior orientation 20
11. Exterior orientation 22
12. Aerial triangulation 30
12.1. Workflow 30
12.2. Automatic UAS triangulation 30
12.3. Measurement of tie and GC points coordinates 33
12.4. Automatic measurement of tie points coordinates 35
12.5. Relative orientation report 48
13. Block adjustment 64
13.1. Preliminary block adjustment 64
13.2. Using self-calibration 65
13.3. Brief residuals report 67
13.4. Creating adjustment report 68
13.5. Adjustment accuracy control 69
14. Distributed Processing 72
14.1. General Information 72
14.2. Workflow of distributed processing 73
14.3. Distributed processing parameters setup 73
14.4. Distributed processing management 75
15. Additional features 79
15.1. Automatic block layout creation 79
15.2. Creating overlap map 80
15.3. Deleting images selectively 82
16. Project processing 84
16.1. Grid creation 84
16.2. Pickets automatic calculating 86
16.3. Points filtering 92
16.4. Building TIN 99
16.5. DEM creation by TIN 101
16.6. Further project processing 102

1. About

1.1. Purpose of the document

This document contains detailed information about UAS data processing in the PHOTOMOD UAS program. The document contains recommendations of processing order, program properties to obtain the best results, and also contains description of additional possibilities when working with UAS data.

1.2. Purpose and main definitions

The PHOTOMOD UAS program is purposed to process data from unmanned aircraft system (UAS). There is a limit on using of the source data when working with program.

Only central projection images with size not more than 60 Mpix could be used a source data.

The following definitions for UAS projects processing are provided in the program:

- preliminary preparing of source images;
- images interior orientation;
- relative orientation of images;
- input and measurement of GCP coordinates;
- Images exterior orientation;
- vectorization;
- stereovectorization;
- building DEM;
- creating orthomosaic;
- creating digital map;
- creating 3d-models.

1.3. Technical Support

The Racurs company technical support provides the actual information about system functionality, characteristics, price and services.

For technical support use one of the following ways:

- e-mail: support@racurs.ru;
- phone: (495) 720-5127;
- fax: (495) 720-5128;
- mail: RACURS Co., Ul. Yaroslavskaya, 13-A, office 15, Moscow, Russia;
- forum: www.forum.racurs.ru

2. Input and output data

2.1. Input data

During the project creation, aerial triangulation and block adjustment the following source data is used:

- *Camera passport* with interior orientation parameters to process central projection images – image focal length and principal point coordinates.

  For *digital* cameras principal points coordinates are set in relation to center or corner of image. Besides image focal length and principal points coordinates, the camera passport also could consist data about lens distortion, which should be considered.

- The *list of GCP coordinates* is necessary for block adjustment. The system provides opportunity to measure GCP coordinates manually and also to perform import of GCP list from a text file.

- The *list of projection centers* coordinates to process central projection images. The program also provides the ability to import on-board data (coordinates) about projection centers from CSV files.

  Block adjustment could be process only by projection centers without using ground control points. It is recommended to use GCP coordinates to increase adjustment accuracy.

- *Raster images*

  For working with images in program , it is recommended to use MS-TIFF internal raster format, which is the TIFF format with overview pyramid (set of subsampled images copies) for higher image display performance.

  The Raster Converter module is used to preliminary raster image processing. It is possible to convert image into internal format both manually, before creating project, and on the stage of adding images into project with saving converted images into active profile resources.

  The following image formats are available to process central projection images:

- JPEG (JPEG);
- Tag Image File Format (TIFF) TIFF и GeoTiff format, included tags for saving of georeference information;
- Windows Bitmap File (BMP);
- Advanced Systems Format (ASF).

- *Information about coordinate system and map projection* – during project creation it is necessary to define coordinate system of GC points. By default there is an International coordinate system database and map projection (see the details in the "GeoCalculator" User Manual);
- also it is possible to use the following exterior data:
  - import of triangulation points from PAT-B and X-POINTS;
  - import of ground control points from text files (`*.txt`, `*.csv`);
  - import of interior and exterior orientation data from metadata;
  - import of external orientation data from PAT-B and CSV-files;
  - GPS data;
  - import additional data from different formats.

2.2. Output data

The program allows to process UAS data and acquire all types of value added photogrammetric products: DEM, 2D and 3D-vectors, orthomosaics.

There are the main output products:

- *Digital Terrain Model (DTM)* – digital cartographic presentation of terrain surface both as regular grid of elevations (DEM) and as triangulated irregular network (TIN). Используются при решении прикладных аналитических задач;
- *3D vector objects*;
- orthophoto production;

There is opportunity to export all photogrammetric products to various formats.

3. Program installation

The **PHOTOMOD UAS** program is stand-alone software, which is not required the **PHOTOMOD** system installation. Also the program could be launched as a module of the PHOTOMOD system.

4. Start of work

Define the folder, in which are placed the sources data before the beginning work in the program. The program allows to place the files with the source data in the folders of Windows file system, as well as in the profile resources.

To start the program perform one of the following:

- in the context menu of System Monitor module (the icon in the system tray) choose the **PHOTOMOD UAS**;
- choose the **Start › Programs › PHOTOMOD6 › UAS**.

5. Interface and its elements

5.1. Work area interface

The GUI contains the following elements:

- the main menu, which contained the all program functionality (*A*);
- the main toolbar is used for quick main program functions access (*B*);
- the optional toolbars is used for quick miscellaneous program functions access (*O*);

Toolbars could be placed only one-lined, horizontal or vertical.

- the 2D-window, used for data displaying, contains the following elements:
  - the toolbar is used for the 2D-window modes managing (*C*);
  - the work area is used for viewing and processing with loaded data of mosaic project (F);
  - the navigation bar is used for fast moving on the specified block images area of mosaic project (D);

By default on launch of the program layers are not shown in the navigation window. If necessary, click the **Navi** tab and choose layers to display.

- the *Layer manager* is used for managing of mosaic project layers (E);
- the axes direction of project coordinate system (*M*);
- the status bar is used for viewing current real (ground) and pixel marker coordinates and brightness, contrast and gamma data adjustment in the work area (*G, K, L*).

When place marker is on the area out of image or on background, brightness is indicated as *NULL*.

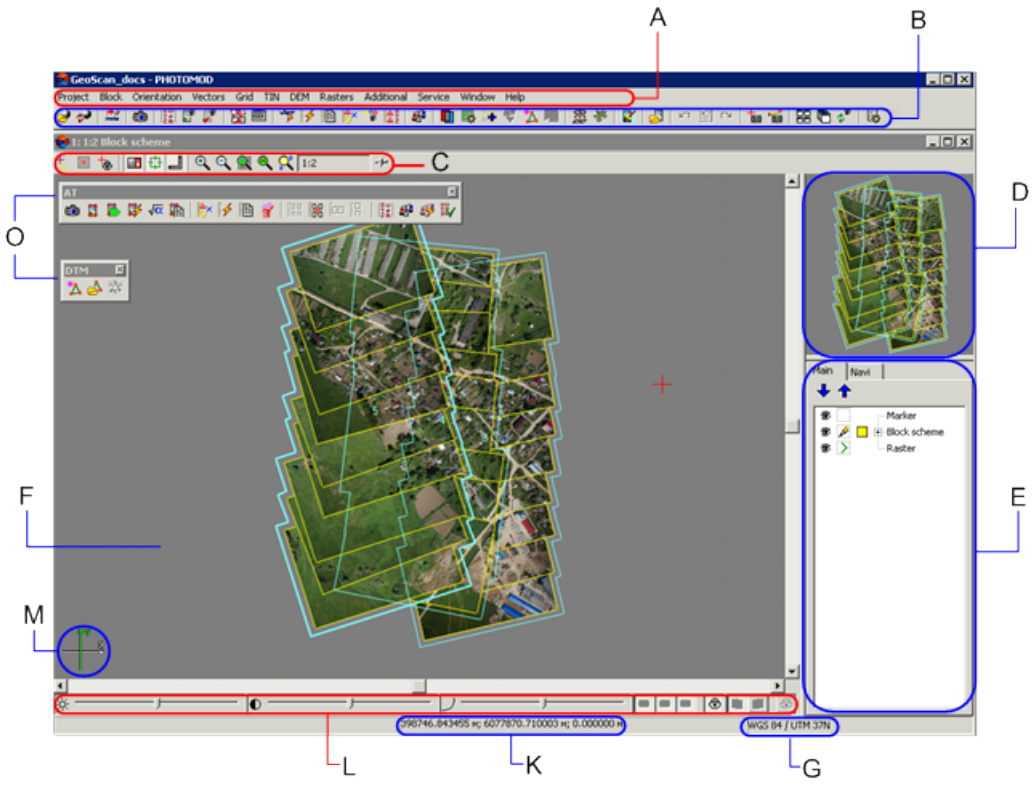


Fig. 1. The main program's window

5.2. Brief description of main menu

The program main menu contains the menu items for mosaic creation, vector data processing, additional applications starting and setting parameters.

Table 1. Main menu

Menu	Function
Project	contains menu items to create, open, save and convert project, and also to get an information about project
Block	allows to form images block of mosaic project

Menu	Function
Orientation	contains menu items to interior orientation, load and use ground control and triangulation points, exterior orientation parameters and also to import and export triangulation points for various formats
Vectors	purposed for creating, editing, import/export of vector data (see the menu description in "Vectorization" User Manual)
Grid	allows to create, open and save regular nodes grid (see the "Create DTM" User Manual)
TIN	allows to create, edit and filter TIN (see the "Creating DTM" User Manual)
DEM	allows to create, edit, filter and import/export DEM (see the "Creating DTM" User Manual)
Rasters	allows to load and georeference raster images, and also to launch additional modules for editing and orthorectification images (see the "Orthophotomaps creation" User Manual)
Service	allows to launch applications, load additional data, set general parameters and edit coordinate systems (see the "General information about system" User Manual)
Windows	allows to open additional toolbars and windows (new 2D-window, Marker and Measurements windows, window of Object Attributes), see the "General information about system" User Manual
Help	allows to start the *"Help"* system
Exit	allows to close the program

5.3. The main toolbar

Table 2. Brief description of main toolbar

Buttons	Function
	allows to open block editor window (see the "Project creation" User Manual)
	allows to reload project to display the last saved version of project
	allows to perform import of exterior orientation results
	allows to open block layout window (see the "Aerial triangulation" User Manual)
	allows to open the Exterior orientation data list
	allows to display all images, loaded to project, in the **Block scheme** window
	allows to display only selected on scheme images in the **Block scheme** window

Buttons	Function
	allows to open block layout window (see the “Aerial triangulation” User Manual)
	allows to open block editor window (see the “Project creation” User Manual)
	allows to start automatic UAS triangulation
	allows to setup and start automatic tie points measurement
	allows to open the relative orientation report
	allows to open the triangulation points window
	allows to load triangulation points
	allows to open the ground control points window
	allows to open the **adjustment** toolbar
	allows to open 2D-window for selected stereopair (see the “Vectorization” User Manual)
	allows to create regular grid or display settings of existed
	allows to start automatic points calculation
	allows to launch the buildings and vegetation filters
	allows to build TIN by points and breaklines (**Ctrl+N, T**)
	allows to build DEM by loaded TIN (**Ctrl+N, D**)
	allows to load georeferenced raster image to project as a layer
	allows to undo the last action (see the “General information about system” User Manual)
	allows to display the list of last actions (see the “General information about system” User Manual)
	allows to redo the last undone action (see the “General information about system” User Manual)
	allows to open the **Marker** window (see the menu description in “Vectorization” User Manual)
	allows to open the **Measurements** window (see the menu description in “Vectorization” User Manual)
	allows to tile 2D-windows
	allows to stack 2D-windows
	allows to refresh all 2D-windows
	allows to open the general program parameters window (see the “General information about system” User Manual)

5.4. The “Orientation” menu

To perform work on data collection for aerial triangulation serves the **Orientation** menu, and also buttons of the main toolbar and of the **AT** additional toolbar.

Table 3. Brief description of the “Orientation” menu

Menu items	Function
Manage projects cameras (**Ctrl+Alt+I**)	allows to input/edit parameters of project cameras, and also to assign cameras to project images
Tie points list (**Ctrl+Alt+T**)	allows to open catalogue of *all measured triangulation points* (GCP, check, tie) with their measurements
GCP list (**Ctrl+Alt+G**)	allows to open catalogue of *all ground control points*, including non-measured on block images
Delete point measurements	allows to choose types of triangulation points to be deleted and delete them
Clear point catalogue	allows to remove the whole list of triangulation points (GCP, check, tie) from triangulation points catalogue
Automatic tie points measurements (**Ctrl+Alt+A**)	allows to measure tie points coordinates in automatic mode
Report on relative orientation (**Ctrl+Alt+R**)	allows to open the report with results of images relative orientation in order to perform analysis and removal of errors in tie points measurements
Automatic UAS triangulation	allows to measure ground points in automatic mode for UAS images
List of exterior orientation parameters	allows to open the Exterior orientation data list
Load projection centres as vectors	allows to load projection centres data as vector point objects and to open them in 2D-window to perform analysis, at that an image name is saved to the `Name` point attribute
Select subblock	allows to select part of block images to perform adjustment
Block adjustment (**Ctrl+Alt+S**)	allows to open the adjustment module, to view adjustment results and errors correction (see the “Block adjustment” User Manual)
Direct georeferecing	allows to perform adjustment using imported exterior orientation parameters
Delete adjustment results	allows to delete adjustment data (see the “Block adjustment” User Manual)
Import exterior orientation	allows to perform import of exterior orientation results
Import orientation from metadata	allows to perform import metadata to a project
Create images georeferencing files	allows to perform export of georeference data after preliminary block exterior orientation and adjustment (to files of ArcInfo World Fileand MapInfo TAB-formats)

Menu items	Function
Import	contains menu items used to import import of triangulation points measurements from files of PAT-B, as well as data import from flight path file
Export	contains menu items used to export of triangulation points measurements to files of PAT-B and X-Points formats, and for export of ties or GCP for further use them in Geomosaic program

5.5. The Block menu

The **Block** menu, buttons of **Block editor** window's toolbar and **Block forming** additional toolbar are used to work with images block in 2D-window.

It includes extended features for images block forming, as well as additional functions for block scheme creation and obtaining of auxiliary data.

Some menu items allow to manage operations with selected images in 2D-window. The **Tools** additional toolbar is used for group selection (highlighting) of images block in 2D-window (see the "Vectorization" User Manual).

Detailed information about **Block** menu items, buttons of **Block editor** window's toolbar and **Block forming** additional toolbar see in the Project creation User Manual.

Table 4. Brief description of the "Block" menu

Menu items	Function
Delete images selectively...	allows to select images in accordance with specified criteria for deleting (see Section 15.3)
Check images	allows to check images, for example, to find images, where radiometric correction is recommended
Mark all images as checked	allows to exclude project images validation - check their presence and compliance to images files during project opening at the next working session
Block layout	contains groups of menu items used to create block layout; allows to refresh, load, save block layout, apply **w/o layout** or **by exterior orientation** modes, build block layout automatically for Unmanned Aerial System (UAS) projects, delete results of automatic block layout (see the "Aerial triangulation" User Manual)
Split to strips	allows to split images block to strips automatically using images names or exterior orientation parameters
Rotate images by block layout	allows to rotate all or selected images of block considering block layout data; images don't rotate if the **w\o layout** was used (see the "Aerial triangulation" User Manual)

Menu items	Function
Set GSD for selected images	allows to define/calculate GSD value in meters for all or selected images of block
Create overlap map...	allows to create map of images and/or strips overlap in new vector layer (see Section 15.2)
Create vector layer from block layout	allows to create vector layers with common block outline, boundaries of all images or selected image of the block
Build pre-regions	allows to create pre-regions by images/stereopairs to provide joint work on a project
Export block layout to KML...	allows to export block scheme to KML format

5.6. The “Block editor” window

The **Block editor** window is used to form a block of project images.

The **Block editor** window contains a table of created strips and images loaded to project and contains tools for images block editing.

The **Block editor** window is synchronized with 2D-window , so all changes in the images list of the **Block editor** (choosing, adding, deleting, moving of strips and images) are shown in the block scheme in 2D-window and vice versa.

Choose the **Windows › Block editor** (**Ctrl+Alt+B**) or click the button on the main toolbar to open the **Block editor** window.

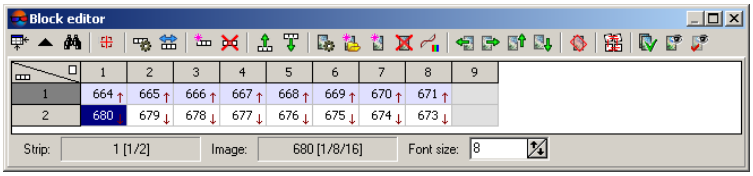


Fig. 2. The “Block editor” window

The **Block editor** window contains the following elements:

- toolbar to form and edit block images;
- the list of existed strips and loaded there images;
- the status bar with the following data:
  - **Strip** – the `Strip name [item No/total]` is displayed for strip selected in the table;
  - **Image** – the `Image name [item No/total in strip/total in block]` is displayed for image selected in the table;
  - **Font size** – allows to change the font size of table text.

To select (highlight) the image in the **Block editor** window click the image name in the list. To select strip click on the name of strip.

To select multiple images\strips use **Shift** and **Ctrl keys**

To highlight several images in 2D-window use additional toolbar of group selection (see the *Tool* section in the "Vectorization" User Manual).

The **Edit › Select all**, **Edit › Invert selection** and **Edit › Cancel selection** allows to change strip or images selection both in block scheme and in 2D-window.

The **Block** menu items, buttons of the **Forming block** toolbar and the toolbar of the **Block editor** window.

Table 5. The toolbox of "Block editor" window

buttons	Function
	allows to change the **Block editor** window size so that window displays all list of strips/images
	allows to show/hide the list of strips/images and the status bar to comfort work with block images in 2D-window (in the **Block editor** window only toolbar displays)
	is used to search for an image by name (part of name)
	allows to select in the list initial images, which contain marker position
	is used to display and edit properties of selected strip (name and type of strip)
	reverse images in the strip order
	allows to add new strip
	allows to remove selected strip
	allows to move selected strip up by one strip
	allows to move selected strip down by one strip
	is used to display and edit properties of selected image
	is used for adding image files, locating in the resources out of active profile, to the selected strip
	is used for adding image files, locating in the resources of active profile, to the selected strip
	allows to remove selected images from project
	is used to radiometric correction of selected image
	allows to move selected images left/right/up/down
	allows to rotate selected images to any angle in relation to source or current image's position in block scheme

buttons	Function
	allows to open the **Block layout** window to build block scheme in 2D-window considering source or acquired data (see the Aerial triangulation User Manual)
	allows to open the ImageWizard window to setup images
	allows to show block images in 2D-window, if they were not displayed during project loading, due to limitation specified in the program's setting window (see the "General system's parameters" User Manual)
	allows to set on/off displaying only selected images mode

6. Workflow of UAS processing

Processing of data acquired by UAS implies performing the following steps:

1. Creating and selecting active profile – creating local profile or creating/connecting network profile to place all project/project group files – resources, and selecting the profile as active.
2. Creating UAS project.
3. Images block forming.
4. Interior orientation.
5. Import of exterior orientation parameters.
6. Aerial triangulation, which includes the correct order of preset algorithm processing.
7. Block adjustment.

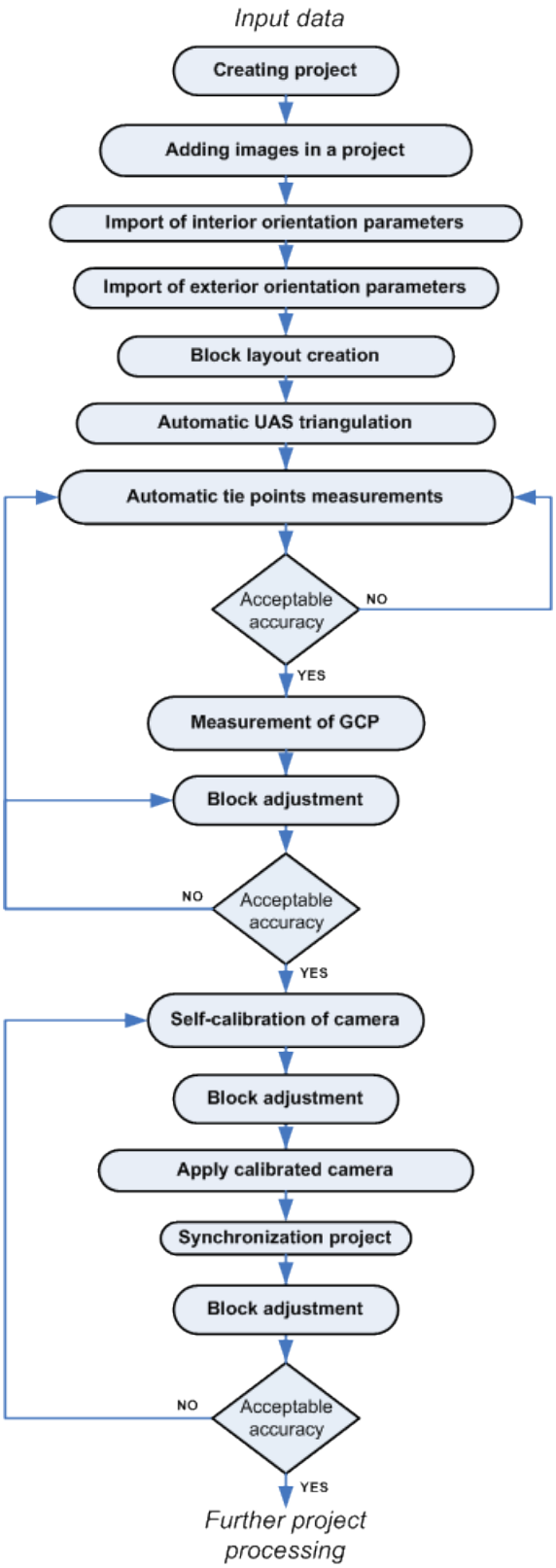


Fig. 3. Workflow of UAS processing

7. Creating and choosing active profile

Prior to work in the program you should create a profile for placing project resources such as project configuration files, images files, files processing projects/project group.

A profile represents a resources tree with the following structure:

- *Root* – profile virtual name.
- *Top level branches* – profile virtual folders – virtual names of physical local or network folders/disks.

  You can specify one physical folder/disk or folders/disks group as a virtual folder (storages group).

  Storage folders are a special type of virtual folder. Resources are automatically placed in storage folders by the program on the basis of free space analysis. Thus, storage folders allow optimization of multiple disk usage for storage resources, which is advantageous when network processing large projects.

- *Resources* – all data of a profile – all subfolders and files of each virtual folder in profile.

Thus, profile resources are placed on any servers, workstations or network disks.

Profiles can be *local* or *network* to organize individual or shared work with projects, respectively.

For profiles creation and organizing resources structure of each profile you can use the Control Panel module.

To view and edit active profile resources is used the PHOTOMOD Explorer module.

To launch these modules is used the **Start › Programms › PHOTOMOD UAS** menu and also the context menu of the System Monitor module (the icon in the Windows system tray).

More details about program resources, recommendations on organizing of local or network work, and about creating profiles and virtual folders connecting see in the “General information” User Manual.

In one work session of the program could be used *only one* active profile.

Close all program modules an perform one of the following to choose *active* profile:

- choose active profile in the **Profile** list from the context menu of the System Monitor module (the icon in the system tray);

- choose active profile with mouse double-click by profile name in the **Profile** list in the Control Panel.

Current active profile is marked in the profile list by the icon.

Restart program after chosen active profile.

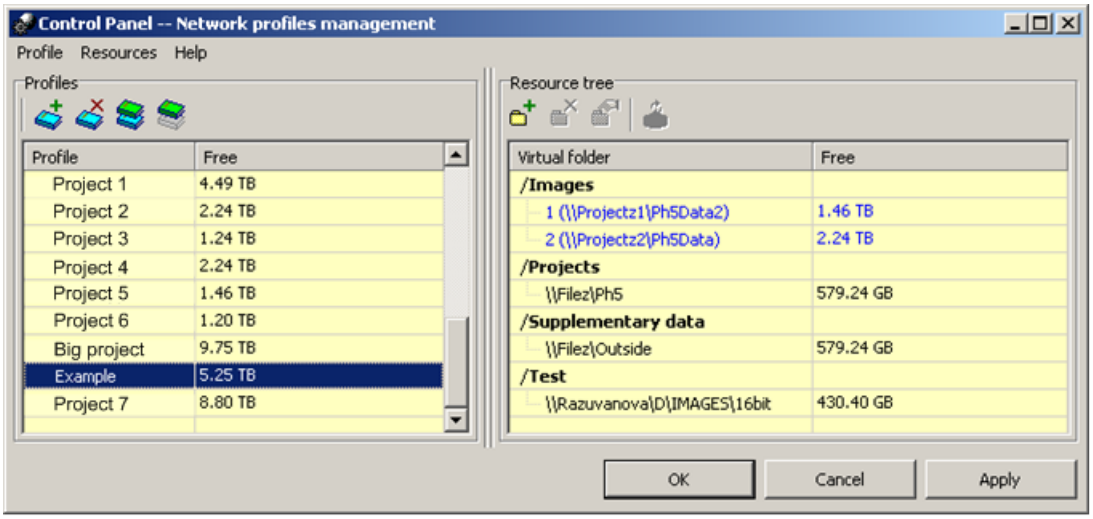


Fig. 4. Creating resources structure of network profile

The folder tree displays in the PHOTOMOD Explorer window after creating profile.

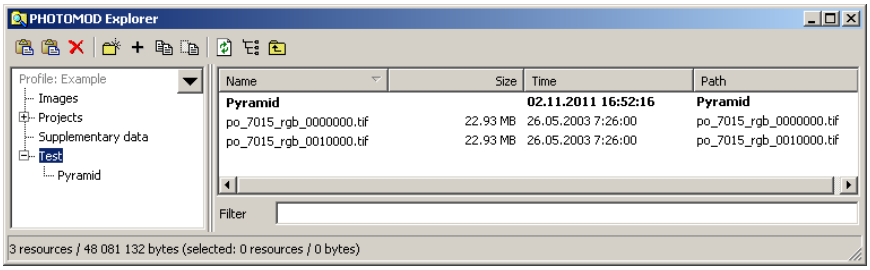


Fig. 5. Resources tree of network profile in the Explorer window PHOTOMOD Explorer

To avoid loss of data, it is not recommended to edit virtual folder for storage group.

8. Project creation

In order to create UAS project perform the following actions:

1. Choose active profile.
2. Start the PHOTOMOD UAS program.

3. Open the **New project** window using one of the following ways:

   - choose **Project › Open/Manage...** (**Ctrl+Alt+O**) or click the button on the main toolbar. The **Manage project** window opens. Click the **New** button;
   - choose **Project › New**.

   The **New project** window opens automatically if there is no existed projects in the active profile.

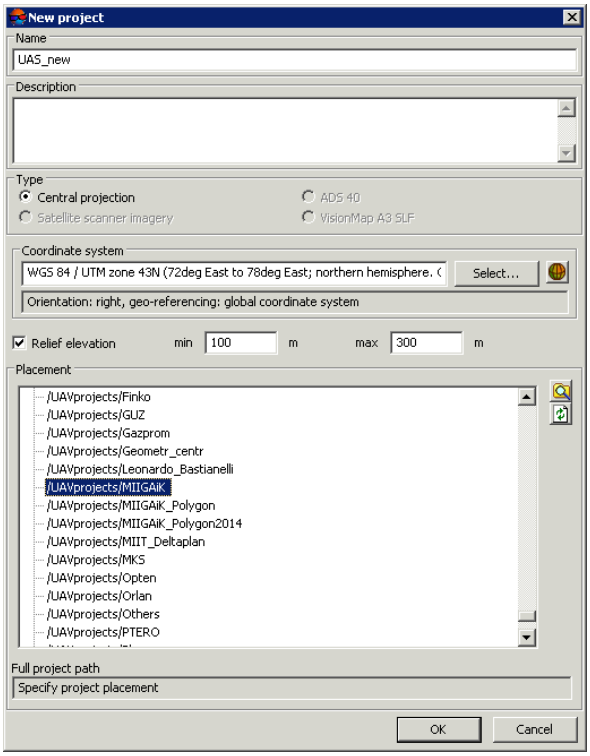


Fig. 6. Creating UAS project.

4. Define a **Name** of new project.

5. [optional] Input to the **Description** section a brief project description, its main features, notes etc.

6. Define a coordinate system using the **Select** button in the **Coordinate system** section.

7. Set on the **Relief elevation** checkbox and specify at least approximately difference of terrain heights on project images in the **min** and **max** input fields.

   If the relief elevation data is unavailable or inaccurate by the time of project creation, the program allows to define the value later in project properties. The relief elevation data is

used to refine a block layout, it is considered during import of exterior orientation parameters and during calculation of ground sample distance (GSD).

8. Choose a folder of active profile resources in the **Placement** list to place a project resources there. The **Full project path** input field shows a name and a path of a project.

9. Click OK to complete a project creation. Service folders and configuration files are created in specified project folder. The first strip create automatically.

See details about project creation in the “Project creation” User Manual.

9. Images block forming

9.1. Image prepearing

Prior to load UAS images to a project it is recommended to prepare them using the Raster Converter module as follows:

1. [if necessary] Perform the radiometric correction.

2. Convert the images to files of inner *MS-TIFF* format.

3. [optional] It is recommended to apply **JPEG compression** with **85 % quality** for output files to save place on hard disk.

4. Choose an individual folder of active profile resources in the **Placement** list to place a converted images.

See the Raster Converter module description in the “General information” User Manual.

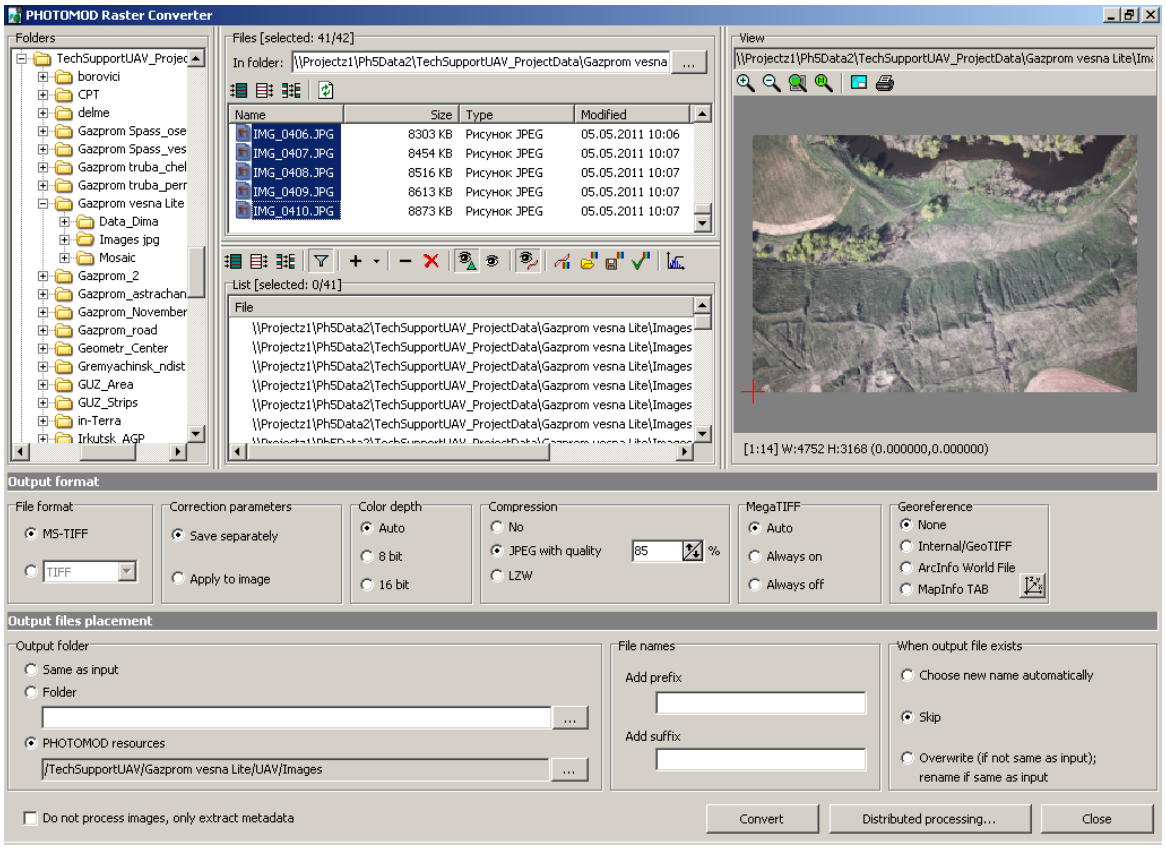


Fig. 7. Images conversion in the Raster Converter module

9.2. Adding images

Perform the following actions to load images to a project and to form a block:

1. Choose **Block › Add images from resources** or click the button in the **Block editor** window to start images adding.

2. Choose images files and click the **Open** button. After that all images are loaded to the first strip.

[optional] To filter showing files choose `Image in TIFF format` in the list rightward to the **Resources name** field.

See a description of images load, setup and editing of images block in the “Project creation” User Manual.

10. Interior orientation

Interior orientation operation includes input or import of camera parameters, specifying of flight direction and angle of camera axes rotation for images of a project.

In order to implement interior orientation perform the following actions:

1. Choose **Orientation › Import exterior orientation** or click the button on main toolbar to get camera data from EXIF-metadata in image files. The **Import orientation from metadata** window opens.

2. Set the **Import interior orientation** and **Import exterior orientation** checkboxes (if EXIF-metadata contains exterior orientation parameters). Click OK.

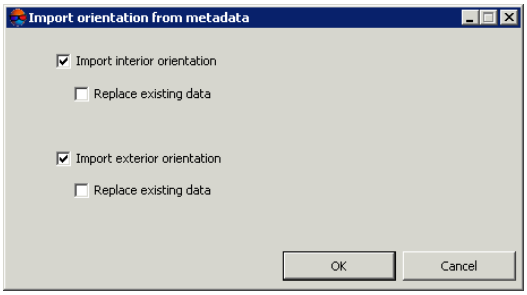


Fig. 8. Import orientation parameters from EXIF-metadata

3. Choose **Orientation › Manage cameras** or click the button of main toolbar to adjust camera parameters and define camera axes direction for project images. The **Manage project cameras** window opens.

4. Choose camera in the list and click the button. The **Camera** window opens to view and edit camera data.

5. [optional] Input camera additional data (if camera passport is available) and click OK.

6. Specify flight direction using window of images preview and define camera axes rotation for project images in the following way:

    1. Choose images in the table which do not require axes rotation.

    2. Set the **Set camera rotation for selected images** checkbox and specify a rotation angle so, that X axis coincides with flight direction.

    3. Click the **Execute** button. Interior orientation is performed automatically.

See detailed description of interior orientation step in the “Aerial triangulation” User Manual.

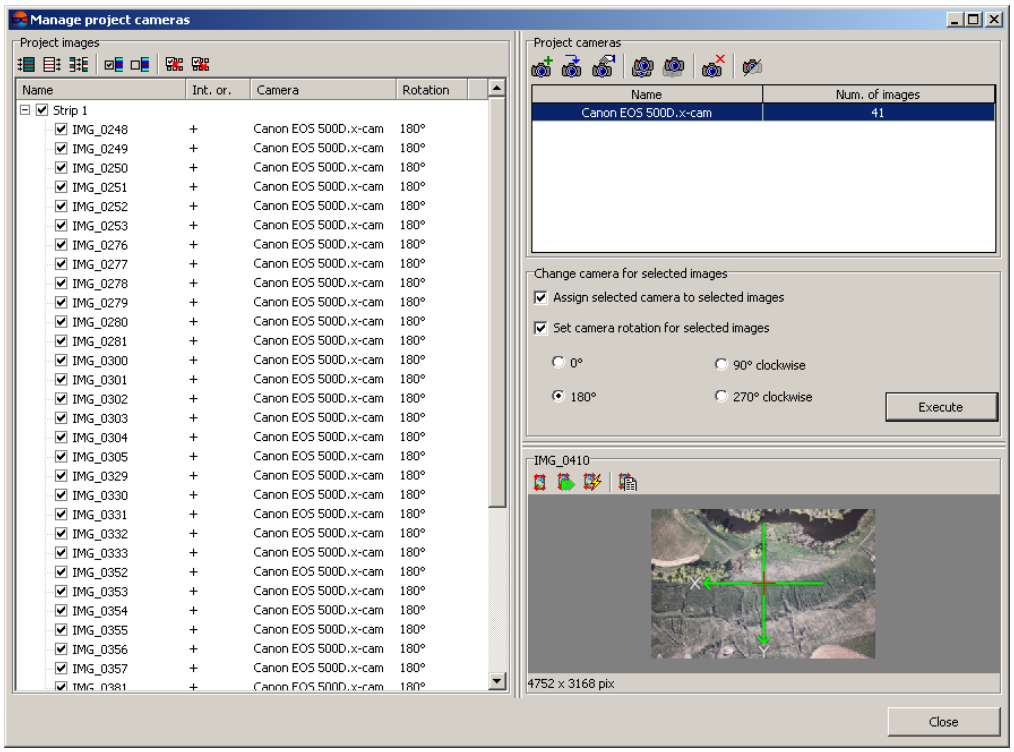

Manage project cameras
Project images
Name
Int. or.
Camera
Rotation
Strip 1
IMG_0248 + Canon EOS 500D.x-cam 180°
IMG_0249 + Canon EOS 500D.x-cam 180°
IMG_0250 + Canon EOS 500D.x-cam 180°
IMG_0251 + Canon EOS 500D.x-cam 180°
IMG_0252 + Canon EOS 500D.x-cam 180°
IMG_0253 + Canon EOS 500D.x-cam 180°
IMG_0276 + Canon EOS 500D.x-cam 180°
IMG_0277 + Canon EOS 500D.x-cam 180°
IMG_0278 + Canon EOS 500D.x-cam 180°
IMG_0279 + Canon EOS 500D.x-cam 180°
IMG_0280 + Canon EOS 500D.x-cam 180°
IMG_0281 + Canon EOS 500D.x-cam 180°
IMG_0300 + Canon EOS 500D.x-cam 180°
IMG_0301 + Canon EOS 500D.x-cam 180°
IMG_0302 + Canon EOS 500D.x-cam 180°
IMG_0303 + Canon EOS 500D.x-cam 180°
IMG_0304 + Canon EOS 500D.x-cam 180°
IMG_0305 + Canon EOS 500D.x-cam 180°
IMG_0329 + Canon EOS 500D.x-cam 180°
IMG_0330 + Canon EOS 500D.x-cam 180°
IMG_0331 + Canon EOS 500D.x-cam 180°
IMG_0332 + Canon EOS 500D.x-cam 180°
IMG_0333 + Canon EOS 500D.x-cam 180°
IMG_0352 + Canon EOS 500D.x-cam 180°
IMG_0353 + Canon EOS 500D.x-cam 180°
IMG_0354 + Canon EOS 500D.x-cam 180°
IMG_0355 + Canon EOS 500D.x-cam 180°
IMG_0356 + Canon EOS 500D.x-cam 180°
IMG_0357 + Canon EOS 500D.x-cam 180°
Project cameras
Name
Num. of images
Canon EOS 500D.x-cam
41
Change camera for selected images
Assign selected camera to selected images
Set camera rotation for selected images
0°
90° clockwise
180°
270° clockwise
Execute
IMG_0410
4752 x 3168 pix
Close

Fig. 9. Performing interior orientation

11. Exterior orientation

If exterior orientation parameters are available for UAS project, you can import them to the project.

Exterior orientation parameters are *coordinates of projection centres and 3 angles*, that allow to specify in whole real position of images in space.

Exterior orientation parameters may be included to EXIF-metadata of images files or separately as a catalogue in a file of text format. Additional information about import of preliminary exterior orientation data from EXIF-metadata is in Section 10.

In order to perform import of exterior orientation data catalogue from a file of text format, do the following:

1. Choose **Orientation › Exterior orientation data list** or click the button on the main toolbar. The **Exterior orientation parameters** window opens.

2. Click the button to import exterior orientation parameters.

3. Choose a file with exterior orientation parameters and click OK. The **Exterior orientation import – Step 1 of 2: File** window opens. The **File name** input field displays selected file placement and name.

To select another file which contains exterior orientation parameters, click the ... button.

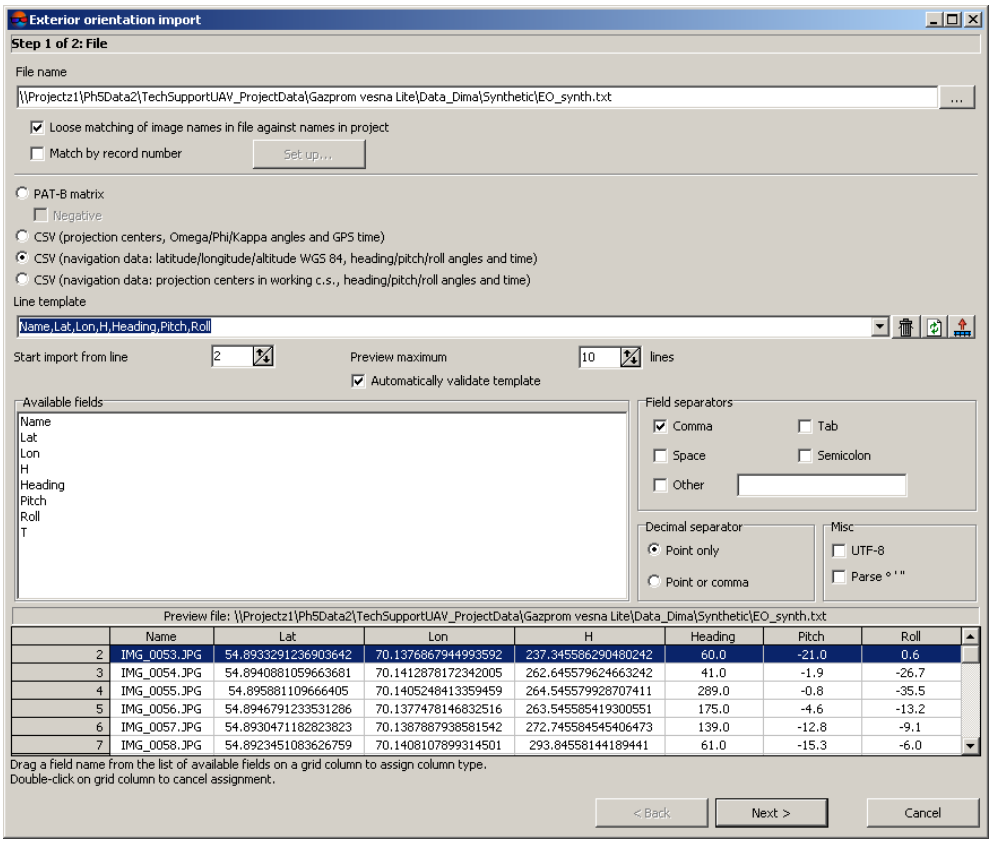


Fig. 10. Setup a file string template for import of exterior orientation parameters

4. [optional] If images names in file and in project are not the same, perform one of the following actions:

   - set on the **Loose matching of image names in file against names in project** checkbox. The program performs search for common substrings and matches images names. For example, it searches for common substring *018_02595* in image name *RGBI_018_02595* in file and image name *018_02595* in project.

     If the **Loose matching of image names in file against names in project** checkbox is set on the image name with file extension is also imported.

   - set on the **Match by record number** checkbox and click the **Setup...** button. The **Match images by numbers** window opens.

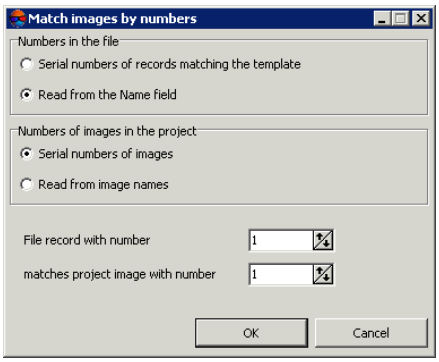


Fig. 11. Images matching by numbers

1. In the **Numbers in the file** section set the following parameters:
   - **Serial numbers of records matching the template** – is used to match a list of records numbers in a file by order;
   - **Read from the Name field** – is used to match a list of records numbers in a file by the last number from the filename.
2. In the **Numbers of images in the project** section set the following parameters:
   - **Serial numbers of images** – used to match a list of records numbers in a project by order;
   - **Read from images names** – used to match a list of records numbers in a project by the last number from the filename.
3. Input necessary parameters to the **File record with the number** and **matches project image with number** input fields.

   For convenient setup of necessary parameters it is recommended to place windows in that way that allows to display on screen a name of the first image in the table of the **Exterior orientation parameters** window, and also allows to display first rows in the **Preview file** table of the **Exterior orientation import** window. It is recommended to place the **Match images by numbers** window in such a way that allow to show both windows mentioned above.

5. The **Line template** field displays the list of fields, contained in each line of imported file:
   - **T** – precise time from GPS-receiver;
   - **Lat** – flight latitude;
   - **Lon** – flight longitude;

- **Alt** – flight altitude;
- **Heading** – flight heading;
- **Roll** – roll;
- **Pitch** – pitch.

The * symbols marks columns with data which is not imported.

In order to setup active template, perform one of the following actions:

- drag by mouse field name from the **Available fields** list to the column of the **Preview file** table. After that the template in the **Line template** field is changes. In order to cancel field selection, double click the column of the **Preview file** table;
- change the template manually in the **Line template** field. At that column types in the **Preview file** table are changed automatically.

The button allows to use the default template `T Lat Lon Alt Heading Roll Pitch`.

The button is used to compare the **Line template** field with data shown in the **Preview file** table.

The active template corresponds only to lines shown in the **Preview file** table.

The button is used to replace specified field names by field values taken from the first line of the **Line template** table.

6. [optional] The **Automatically validate template** checkbox is set on by default that allows to select current template automatically. In order to configure the template for file containing lines with different columns number, set off the **Automatically validate template** checkbox and configure the template in the **Line template** field manually.
7. [optional] To specify a line from to start data import, define the value of the **Start import from line** parameter.
8. [optional] To display necessary number of lines in the **Preview file** table, set the **Preview maximum** parameter. Default number of lines is 10.
9. In the **Available fields** section select necessary field name and drag it to the table column. To cancel the field name double click the column header.

10. In the **Field separators** section set on one or multiple checkboxes to specify possible fields delimiter symbol: **Comma**, **Space**, **Tab**, **Semicolon** or **Other** delimiters. Default settings are comma and space.

11. In the **Decimal separator** section setup the following parameters:

    - **Point only** – to use point only as a decimal separator in coordinates;
    - **Point or comma** – to use both point and comma as a decimal separator in coordinates.

    If comma is used as **Field separator**, it is not recommended to use comma as **Decimal separator**, since it may cause import of incorrect data.

12. [optional] In the **Misc** section set the checkbox:

    - **UTF-8** – is used to recognize text in *Unicode* encoding;

    Unicode – symbols encoding format that allows to provide symbols of almost all written languages.

    - **Parse ° ’ “** – is used to recognize records of projection centers or GCP.

    When using this parameter it is highly recommended to check points coordinates recognition correctness after import. To do this select any point in 2D-window and check coordinates values in the **Marker** window (see the Vectorization User Manual).

13. Choose one of the following formats to specify a type of imported file:

    - **PAT-B matrix** – file containing coordinates of projection centers and rotation matrices.
    - **CSV (projection centers, Omega/Phi/Kappa angles and GPS-time)** – file containing coordinates of projection centers in any coordinate system, as well as exterior orientation parameters, and precise time from GPS-receiver.

    CSV format is exchange text format with `*.csv` extension, which is supported by major applications in different industries. It is used as exchange format when special geospatial data formats are not applicable for some reason.

    - **CSV (navigation data: latitude/longitude/altitude WGS-84, heading/pitch/roll angles and time)** – file containing navigation data (latitude/longitude set in degrees, altitude in meters, angles in degrees, radians or gons) and precise time from GPS-receiver.

To perform import of exterior orientation parameters it is necessary that a project is in coordinate system consistent with WGS-84 coordinate system.

- **CSV (navigation data: projection centers in working c.s., heading/pitch/roll angles and time)** – file containing navigation data (coordinates of projection centers in project coordinate system, angles in degrees, radians or gons) and precise time from GPS-receiver.

14. Click the **Next** button. The **Exterior orientation import – Step 2 of 2: Import settings** window opens.

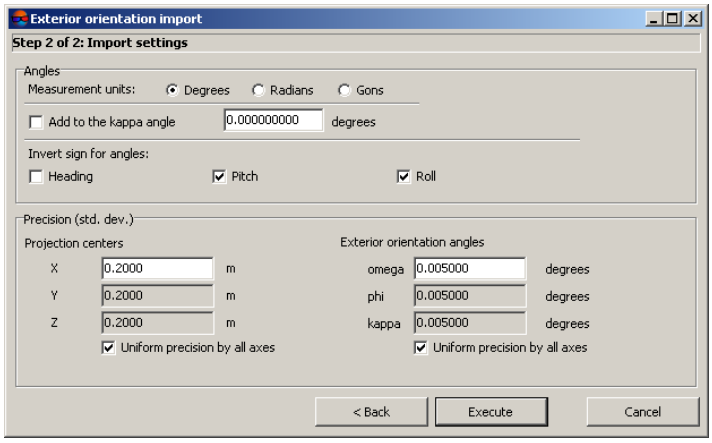


Fig. 12. Import options of exterior orientation parameters

Define the following parameters of datum:

1. In the **Angles** section specify measurement units for angles coordinates according to data of the file to be imported:

   - **radians**;
   - **degrees**;
   - **gons** – plane angle measurement unit that equals to 1/100 of flat right angle measurement unit, and full angle is 400 gons.

2. [optional] In order to make correction to kappa angle, set on the **Add to the kappa angle** checkbox and input correction value to the input field.

3. [optional] In order to **Invert sign** for angles **Omega**, **Phi** and/or **Kappa**, set on corresponding checkboxes.

4. [optional] **Relief elevation** is automatically set equal to values specified in the project settings (see the "Project creation" User Manual). To change values of relief elevation input then in **min** and **max** fields (in meters).

If the **max** value bigger than projection centers coordinates elevations, the error message displays.

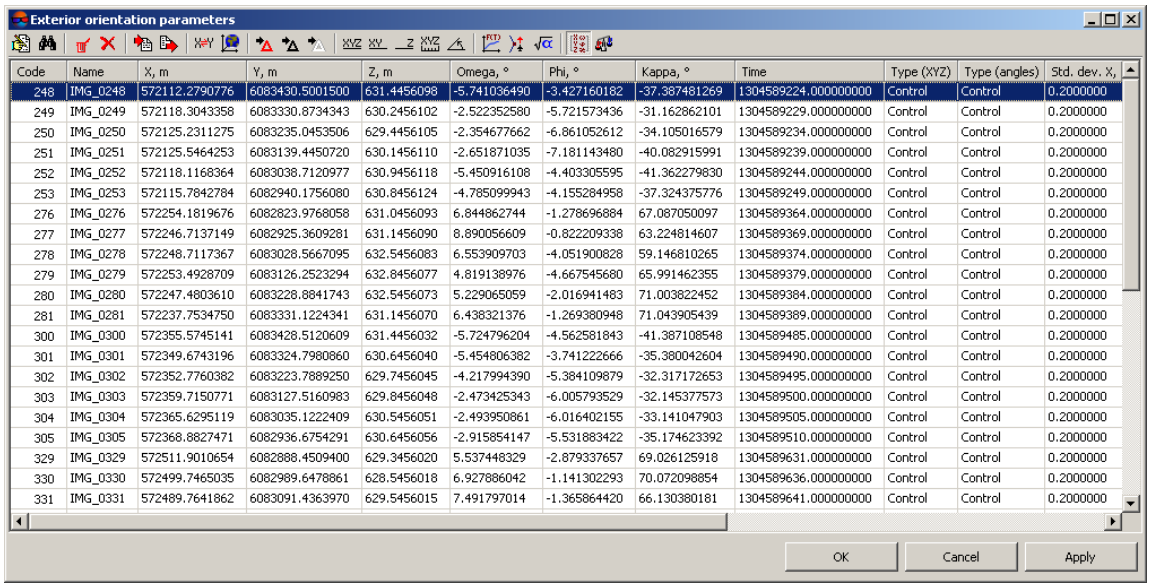
5. [optional] In the **Precision (std. dev.)** section change precision of a priori RMS of measurements of projection centers coordinates and exterior orientation angles.

6. [optional] In order to cancel automatic setting of the same precision by all axes, set off the **Uniform precision by all axes** checkbox.

15. Click the **Execute** button. Exterior orientation parameters obtained after the import are displayed in the table of the **Exterior orientation parameters** window.

16. Click the **Apply** button in the **Exterior orientation parameters** window to save exterior orientation parameters folder in the project.

17. Click OK. The window closes block scheme by exterior orientation automatically (to build initial block layout).



Code	Name	X, m	Y, m	Z, m	Omega, °	Phi, °	Kappa, °	Time	Type (XYZ)	Type (angles)	Std. dev. X,
248	IMG_0248	572112.2790776	6083430.5001500	631.4456098	-5.741036490	-3.427160182	-37.387481269	1304589224.000000000	Control	Control	0.2000000
249	IMG_0249	572118.3043358	6083330.8734343	630.2456102	-2.522352580	-5.721573436	-31.162862101	1304589229.000000000	Control	Control	0.2000000
250	IMG_0250	572125.2311275	6083235.0453506	629.4456105	-2.354677662	-6.861052612	-34.105016579	1304589234.000000000	Control	Control	0.2000000
251	IMG_0251	572125.5464253	6083139.4450720	630.1456110	-2.651871035	-7.181143480	-40.082915991	1304589239.000000000	Control	Control	0.2000000
252	IMG_0252	572118.1168364	6083038.7120977	630.9456118	-5.450916108	-4.403305595	-41.362279830	1304589244.000000000	Control	Control	0.2000000
253	IMG_0253	572115.7842784	6082940.1756080	630.8456124	-4.785099943	-4.155284958	-37.324375776	1304589249.000000000	Control	Control	0.2000000
276	IMG_0276	572254.1819676	6082823.9768058	631.0456093	6.844862744	-1.278696884	67.087050097	1304589364.000000000	Control	Control	0.2000000
277	IMG_0277	572246.7137149	6082925.3609281	631.1456090	8.890056609	-0.822209338	63.224814607	1304589369.000000000	Control	Control	0.2000000
278	IMG_0278	572248.7117367	6083028.5667095	632.5456083	6.553909703	-4.051900828	59.146810265	1304589374.000000000	Control	Control	0.2000000
279	IMG_0279	572253.4928709	6083126.2523294	632.8456077	4.819138976	-4.667545680	65.991462355	1304589379.000000000	Control	Control	0.2000000
280	IMG_0280	572247.4803610	6083228.8841743	632.5456073	5.229065059	-2.016941483	71.003822452	1304589384.000000000	Control	Control	0.2000000
281	IMG_0281	572237.7534750	6083331.1224341	631.1456070	6.438321376	-1.269380948	71.043905439	1304589389.000000000	Control	Control	0.2000000
300	IMG_0300	572355.5745141	6083428.5120609	631.4456032	-5.724796204	-4.562581843	-41.387108548	1304589485.000000000	Control	Control	0.2000000
301	IMG_0301	572349.6743196	6083324.7980860	630.6456040	-5.454806382	-3.741222666	-35.380042604	1304589490.000000000	Control	Control	0.2000000
302	IMG_0302	572352.7760382	6083223.7889250	629.7456045	-4.217994390	-5.384109879	-32.317172653	1304589495.000000000	Control	Control	0.2000000
303	IMG_0303	572359.7150771	6083127.5160983	629.8456048	-2.473425343	-6.005793529	-32.145377573	1304589500.000000000	Control	Control	0.2000000
304	IMG_0304	572365.6295119	6083035.1222409	630.5456051	-2.493950861	-6.016402155	-33.141047903	1304589505.000000000	Control	Control	0.2000000
305	IMG_0305	572368.8827471	6082936.6754291	630.6456056	-2.915854147	-5.531883422	-35.174623392	1304589510.000000000	Control	Control	0.2000000
329	IMG_0329	572511.9010654	6082888.4509400	629.3456020	5.537448329	-2.879337657	69.026125918	1304589631.000000000	Control	Control	0.2000000
330	IMG_0330	572499.7465035	6082989.6478861	628.5456018	6.927886042	-1.141302293	70.072098854	1304589636.000000000	Control	Control	0.2000000
331	IMG_0331	572489.7641862	6083091.4363970	629.5456015	7.491797014	-1.365864420	66.130380181	1304589641.000000000	Control	Control	0.2000000

Fig. 13. List of exterior orientation parameters

The program provides possibility to create a block scheme by UAS images if angular exterior orientation parameters of block images are specified with low accuracy or are unavailable. For this operation it is necessary to use the button of the **Exterior orientation parameters** window toolbox. For each highlighted image the program calculates the direction from previous to next center in a strip (for utmost images of a strip – from adjacent image to the current one) and kappa angle is setup from this direction.

If the survey time is available the correct images order is checked, otherwise images in strips should be located in chronological order only.

In order to eliminate blunders in block scheme building by exterior orientation parameters, perform the following actions:

1. Refine block layout parameters, by performing the following actions:

    1. Click the button on the main toolbar. The **Block layout** window opens.

    2. Choose the **By ext. or.** mode and click the **Apply** button.

    See a description of block layout creation in the "Aerial triangulation" User Manual.

2. Import exterior orientation parameters from a file of text format once more and refine import parameters.

3. To split images into strips by imported exterior orientation parameters (if any), perform the following:

    1. Choose **Block › Split into strips › By exterior orientation data**. The **Split into strips by exterior orientation** window opens.

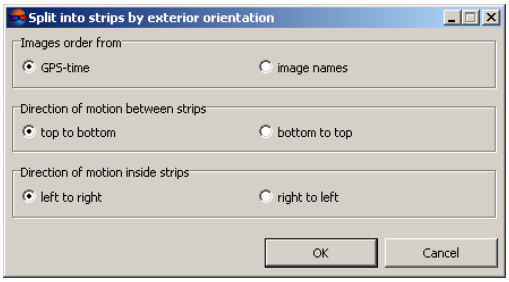


Fig. 14. Split images into strips by exterior orientation

    2. Specify the following parameters of splitting images into strips:

        - **Images order from** by GPS-time or image names;

        If the GPS-time is unavailable for part of images, they add to the separate strip automatically;

        - **Direction of motion between strips** – up to down or bottom up;

        - **Direction of motion inside strips** – left to right or right to left.

    3. Click OK. Block scheme rebuilds by set parameters.

Block scheme, created using exterior orientation is an initial block layout and requires further refining by tie/GC points (see Section 12).

12. Aerial triangulation

12.1. Workflow

On aerial triangulation step you can perform tie points measurement in automatic mode and relative orientation, as well as GC point measurement (if coordinates are available).

For automatic *tie points* coordinates measurement and relative orientation, perform the following actions:

1. Execute automatic UAS triangulation to refine initial block scheme.

2. Perform automatic measurement of tie points using build-in set of parameters for UAS.

12.2. Automatic UAS triangulation

For automatic UAS triangulation do the following:

1. Choose **Orientation › Automatic UAS triangulation**. The **UAS automatic triangulation** window opens.

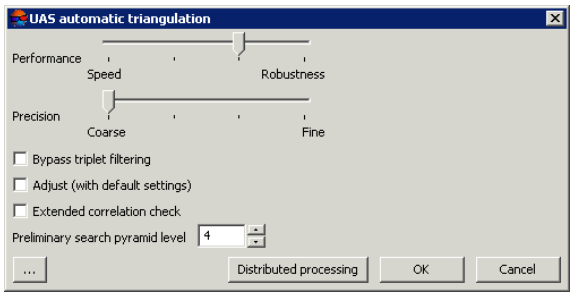


Fig. 15. Settings of the UAS automatic triangulation

2. Set the following options of the UAS automatic triangulation:

   - **Performance** – choose **Speed** for less points and higher speed or choose **Robustness** for more points and less speed;

   - **Precision** – choose *Coarse* to increase of the parallax allowance or choose Fine for better precision and less allowance;

   - **Bypass triplet filtering** – set the checkbox off to filter points in the triple overlapping;

     It is used to blocks with big overlaps inside strips, where this filtering could make adjustment results worse.

- **Adjust (with default settings)** – set the checkbox on to adjust the block after the UAS automatic triangulation.
- **Extended correlation check** – allows to perform the points correlation check by reverse stereopair and also to check correlation coefficient values for points transferred from other stereopairs (see the "Aerial triangulation" User Manual);
- **Preliminary search pyramid level** – allows to set the image pyramid level used to preliminary search of points.

The '0' level is used to source image.

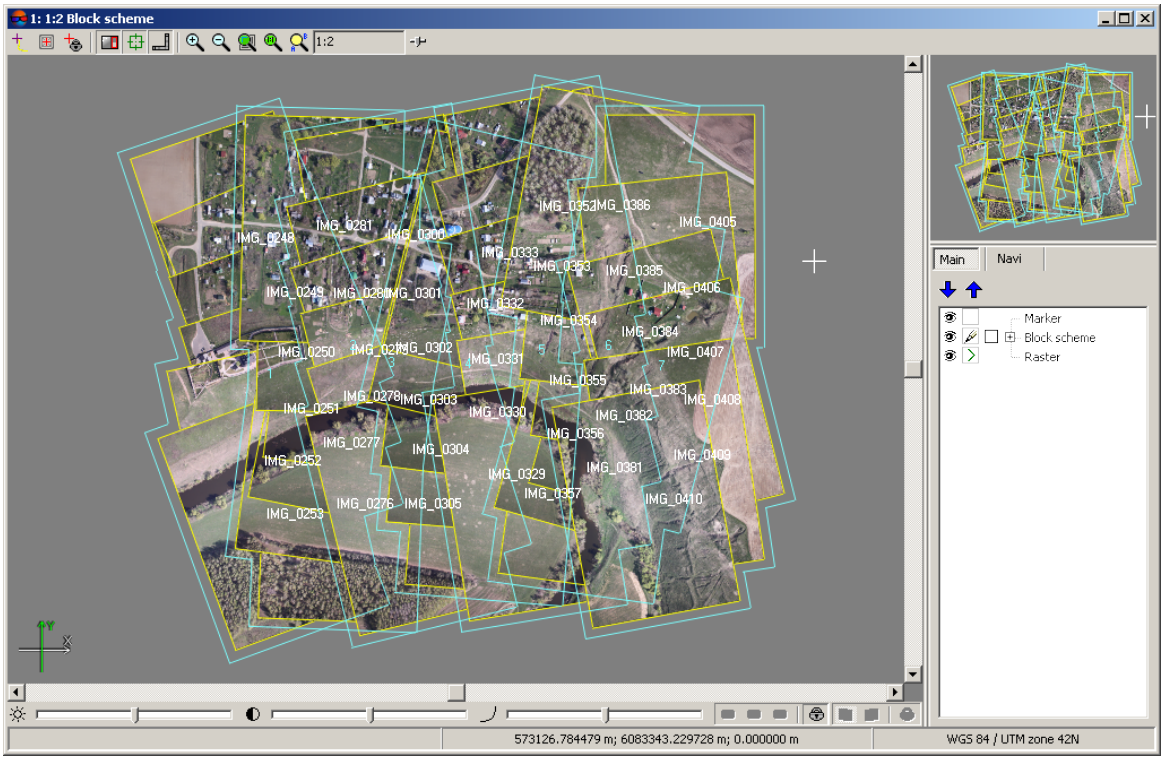


Fig. 16. Block scheme after automatic UAS triangulation

3. Click OK for automatic UAS triangulation in normal mode.

   To distribute the triangulation process do the following:

   1. Change settings and run the distributed processing server/client (see the "*Distributed processing*" chapter in the "General information about system" User Manual).
   2. Press the button in the **Tasks** part of the **Monitor for distributed processing** window to start tasks automatically after theirs creating.

3. Click the **Distributed processing** button. The **Distributed processing parameters** window opens.

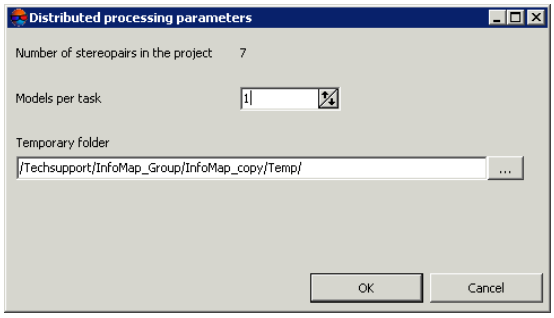


Fig. 17. Distributed processing parameters of the UAS automatic triangulation

The number of stereopairs in the project shows automatically in the window.

4. Define the number of **Models per task** so as one task uses one kernel.

5. In the **Temporary folder** field select an empty folder for temporary data.

Folder must be available on the all utilized workstations.

6. Click OK. Distributed processing tasks are creating and information about number of tasks is shown on the screen

If the **Auto run tasks** mode is set of in the **Monitor of distributed processing** window, processing will not start.

4. Choose **Orientation › Report on relative orientation** or click the button to evaluate initial triangulation in relative orientation report.

Residuals of UAS triangulation are considered during setting parameters of automatic tie points measurement.

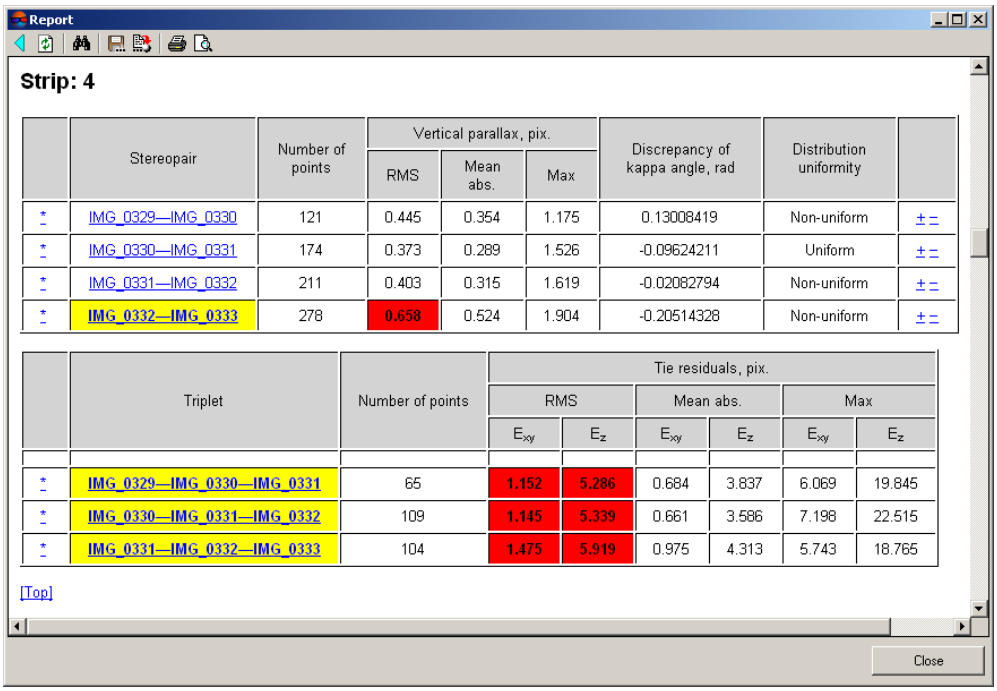


Fig. 18. Evaluation of residuals of automatic UAS triangulation

12.3. Measurement of tie and GC points coordinates

For automatic tie points measurement with UAS preset perform the following actions:

1. Choose **Orientation › Automatic tie points measurement** or click the button. The **Automatic tie points measurement** window allows to setup of points measurement parameters.

2. Setup main and additional parameters for automatic tie points measurement considering the following recommendations:

   - As a base parameters set for tie points measurement for UAS projects it is recommended to use a pre-set UAS parameters set, that ensures satisfying result even with poor quality images. To load a set of UAS parameters click the arrow next to the button to open drop-down menu and choose **UAS**.

     See detailed description of main and additional parameters of automatic tie points measurement in the “Section 12” User Manual.

   - You should remember that each flight is unique, uses different UAS, cameras, on-board GPS/IMU with different accuracies. That is why output images have different quality and spatial geometry. Thus, you should setup parameters of automatic measurement considering particular project features.

3. Choose **Orientation › Relative orientation report** or click the button to analyse and correct measurements errors in relative orientation report.

4. [optional] Repeat steps 2-3 if necessary, picking optimal parameters of tie points measurement and verifying measurement results using relative orientation report.

   For example, for images of good quality you can set more “rigid” parameters and start automatic tie points measurement twice: first to measure the points inside strips, then – between strips.

   The example below shows a set of images of good quality, so more “rigid” parameters were set and automatic tie points measurement was performed twice: first to measure the points inside strips, then – between strips.

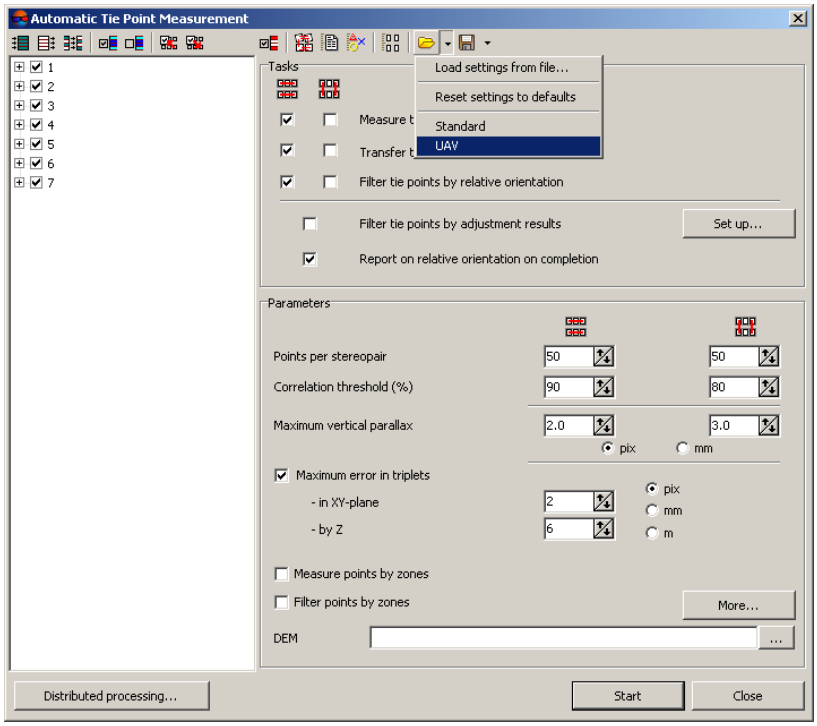


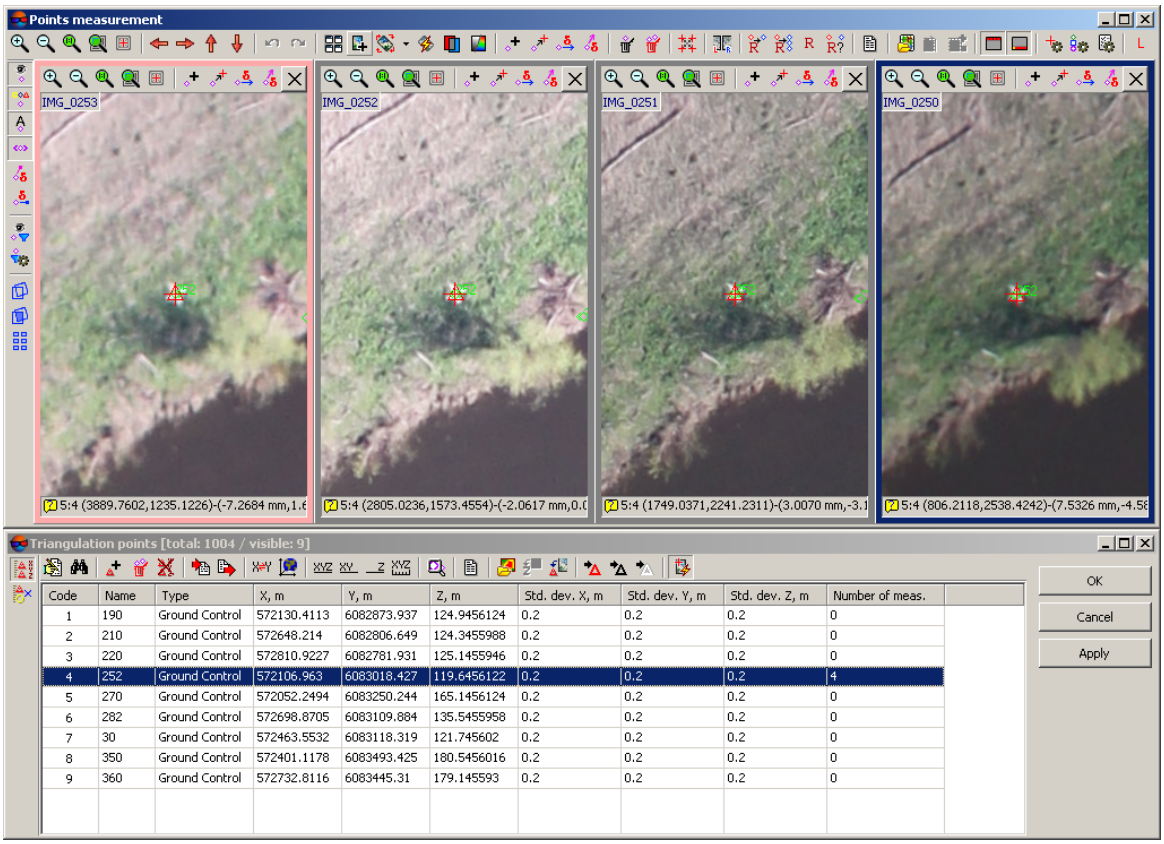
Fig. 19. Example of parameters set for automatic tie points measurement for UAS project

In order to measure *GCP* perform the following actions:

1. choose **Orientation › GCP list** or click the button to input GCP coordinates manually or to import GCP coordinates catalogue from file of text format.

2. Measure GCP on project images in the **Points measurement** module.

   See details about input/import/measurement of GCP in the “Aerial triangulation” User Manual.



Code	Name	Type	X, m	Y, m	Z, m	Std. dev. X, m	Std. dev. Y, m	Std. dev. Z, m	Number of meas.
1	190	Ground Control	572130.4113	6082873.937	124.9456124	0.2	0.2	0.2	0
2	210	Ground Control	572648.214	6082806.649	124.3455988	0.2	0.2	0.2	0
3	220	Ground Control	572810.9227	6082781.931	125.1455946	0.2	0.2	0.2	0
4	252	Ground Control	572106.963	6083018.427	119.6456122	0.2	0.2	0.2	4
5	270	Ground Control	572052.2494	6083250.244	165.1456124	0.2	0.2	0.2	0
6	282	Ground Control	572698.8705	6083109.884	135.5455958	0.2	0.2	0.2	0
7	30	Ground Control	572463.5532	6083118.319	121.745602	0.2	0.2	0.2	0
8	350	Ground Control	572401.1178	6083493.425	180.5456016	0.2	0.2	0.2	0
9	360	Ground Control	572732.8116	6083445.31	179.145593	0.2	0.2	0.2	0

Fig. 20. GCP measurement in the Points measurement module

12.4. Automatic measurement of tie points coordinates

12.4.1. Main parameters of tie points measurement

The **Automatic tie points measurement** window allows to use presets for tie points coordinates measurement (for airborne and UAS images) or to manually select optimal combinations of main and additional parameters used for automatic tie points search, measurement and filtering.

Open the **Automatic tie points measurement** window using one of the following ways:

- choose **Orientation › Automatic tie point measurement**;
- click the button of the main program toolbar.
- click the button of the **AT** additional toolbar.

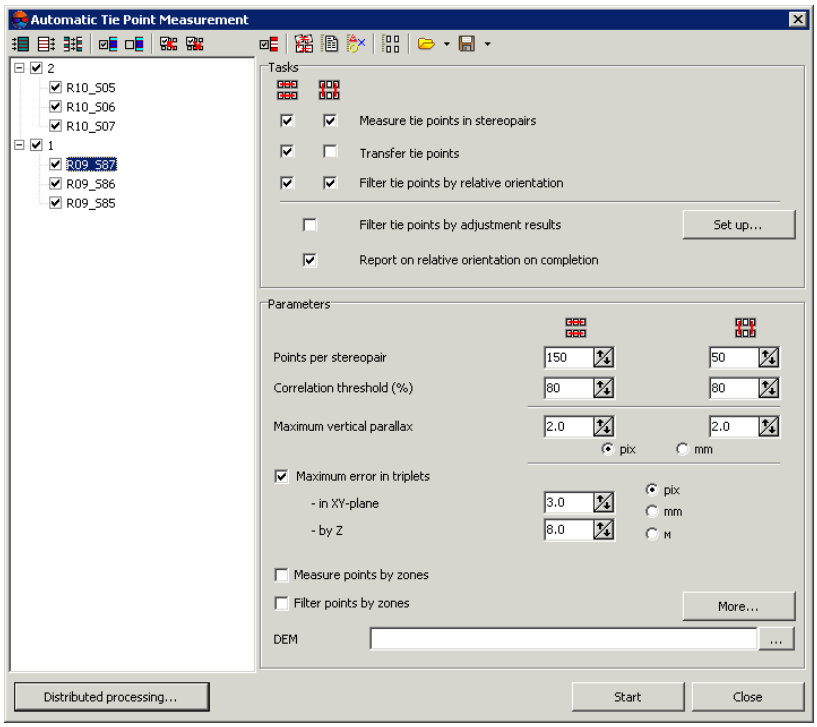


Fig. 21. The “Automatic tie points measurement” window

The **Automatic tie points measurement** window includes the following interface elements:

- the images selection toolbar used to open auxiliary windows, to save and load sets of parameters;
- a list of project images allows to select images, scheduled to perform automatic measuring of tie points coordinates;
- the **Tasks** section used to specify main actions (measurement, transfer, filtering, reporting) during operation of automatic measuring of tie points coordinates;
- the **Parameters** section used to specify main parameters of automatic measuring of tie points coordinates;
- the **More** button used to setup additional parameters of measuring of tie points coordinates;
- the **Start** button used to launch an operation of tie points measurement and to perform relative orientation in automatic mode;
- the **Distributed processing** button is used for automatic tie points measurement in distributed processing mode.

The program provides the following buttons in the toolbar to work with auxiliary windows:

- – allows to choose stereopairs where there is no tie points coordinates measurements, and their adjacent images;
- – allows to open the block layout window to create a block layout or update it;
- – allows to open the **Relative orientation report settings** window used to specify parameters and view a relative orientation report;
- – allows to open the Triangulation points window used to view a list of triangulation points;
- – allows to open the **Points measurement** module and open automatically open images selected in the list, if more than 6 images are chosen. Otherwise, an in-strip stereopair with image selected in the list will be opened.

To save and load sets of main and auxiliary parameters the program provides the following buttons:

- – is used to load a set of parameters from `*.x-ini` file saved previously in active profile resources or out of them.

  The arrow located next to the button allows to open a drop-down menu containing the following items:

  - **Load settings from file** allows to open the **Load settings** window used to load a set of parameters from `*.x-ini` file, located out of active profile resources;
  - **Reset settings to defaults** allows to use default settings;
  - **UAS** allows to load preset of parameters optimally selected for UAS images;

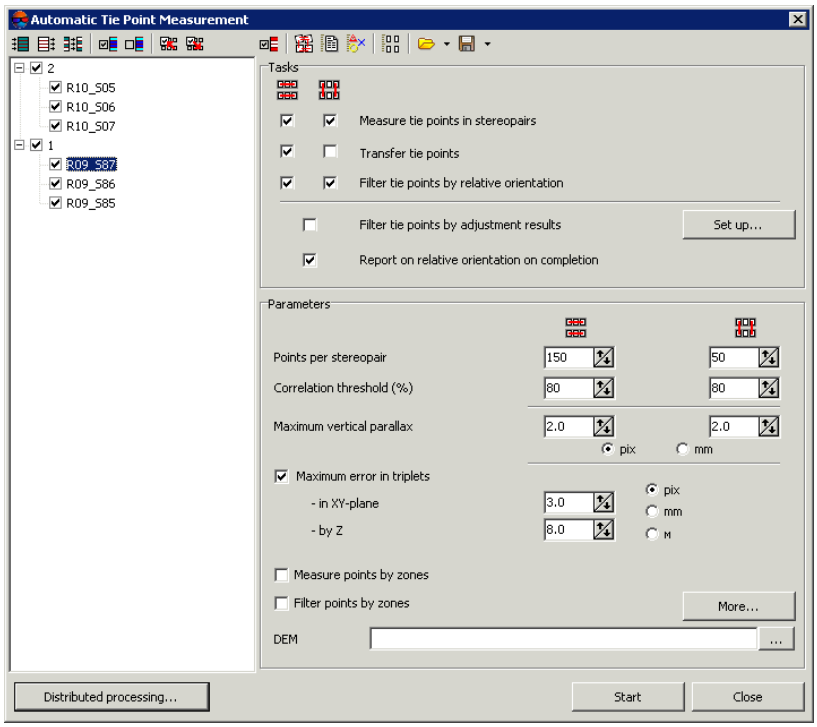


Fig. 22. Example set of basic parameters for the UAS

During tie points measurement for UAS images it is recommended to perform search in two steps: on the first one - search for tie points only inside strips, on the second step – just between strips, at that it is not recommended to use the **Transfer tie points** option.

- **Standard** allows to load preset of parameters optimally selected for airborne images.

- – used to save setting of main and additional parameters to a file with `*.x-ini` extension in active profile resources.

To save setting to a file with `*.x-ini` extension located out of active profile resources, open drop-down list by clicking the arrow next to the button and choose **Save settings to file...**.

Setting saving is used to create files with settings directed to work with certain type of block, kind of images, or terrain, etc.

The **Tasks** section is used to specify the following actions during automatic tie points measurement:

- **Measure tie points in stereopairs** allows to perform search and measurement of tie points coordinates on in-strip and inter-strip stereopairs;

A stereopair is called in-strip, if it is formed by two adjacent images in a strip, and *inter-strip* is any other stereopair of a block.

- **Transfer tie points** allows to perform transfer of measured points to adjacent stereopairs (transfer of points located in triple overlap area to adjacent models), and transfer of tie points to adjacent strips;

- **Filter tie points by relative orientation** allows to perform points filtering that have measurements, exceeding specified values of errors thresholds;

  Points check if to filter them or not, is performed sequentially by errors type – first check - whether the point falls within specified correlation threshold, then whether it does not exceed maximal vertical parallax value, and finally, search for triplet errors is performed, if the appropriate option is specified.

  Check for exceeding correlation threshold is applied *only* to new points (if measured points are already available). In order to check *all* points whether they exceed correlation threshold, set the additional **Delete points with correlation below threshold** checkbox on the **Rejection** tab in the **Tie point measurement parameters** window of additional parameters.

It is possible to perform actions with tie points inside strips, between strips, or not perform at all.

- **Filter tie points by adjustment results** allows to perform automatic block adjustment using specified parameters and to filter measured tie points after that;

  Points filtering using adjustment results is applied if there are blunders on images between strips. The filtering is performed using residuals tolerance specified in the **Adjustment parameters** window, see the "Block adjustment" User Manual.

- **Report on relative orientation on completion** allows to open the **Relative orientation report** window automatically to view and edit tie points measurements just after completing of automatic relative orientation.

The **Parameters** section allows to make the following settings of automatic measurement of tie points coordinates:

- **Points per stereopair** – allows to specify a number of points to be measured on in-strip and inter-strip stereopairs;

  The resulting number of measured points may be both greater than a predetermined amount – due to points transfer from adjacent stereopairs, and less due to the subsequent rejection of points. Default value is 30 points on each in-strip images pair, and 10 points – in inter-strip overlap. The minimum number of points to control the vertical parallax residual is 6.

  The **Points per stereopair** parameter depends on settings defined on the **Miscellaneous** tab in the Tie point measurement parameters window.

- **Correlation threshold** (%) – minimal acceptable value of correlation coefficient for tie points, that will be selected during automatic search;

Recommended values lie in range from 90 to 95%. In contrast to all other filtering criteria, this parameter directly influences on operation of points measurement and transfer. Check for exceeding of correlation threshold is performed only for new points (if there are already measured points). To check all measured points for exceeding of correlation threshold (usually, at final stage of collecting measurements of tie points) set the additional **Delete points with correlation below threshold** checkbox on the **Rejection** tab in the additional parameters window.

- **Maximum vertical parallax** (in pixels or mm) – threshold value for rejection executed after points measuring/transfer. On each step of rejection process, the program searches for the point with maximal Y-parallax on the stereopair and rejects it. After that, it makes relative orientation once more and the iteration is executed until maximal Y-parallax exceeds the parameter specified here, or until 6 points or less remain on stereopair. Recommended value is a pixel size;

- **Maximum error in triplets in XY-plane and by Z** (in pixels, meters or mm) – threshold discrepancy of points measurements on adjacent stereopairs in triple overlapping zone of adjacent images in a strip.

- **Measure points by zones** – allows to apply a method of sequential measurement by zones of overlap area. If the checkbox is set of, points search is performed over the whole area of images overlap. The program allows to select zones and define their size in the **Zones** section on the **Miscellaneous** tab of the additional parameters window;

- **Filter points by zones** – is used to filter points in stereopair zones sequentially;

The operation provides filtering the worst (by parallax) points on stereopair, passing zone by zone one after another. So the worst point on stereopair is found and deleted first, then the worst one in the next zone and so on. Uniformity of point's distribution on stereopair is also verified in such a way.

- **DEM** – allows to choose a DEM (if any) to consider its data during automatic tie points measurement. For this it is necessary to have saved adjustment results available.

This parameter allows to use DEM for calculation of the true position of the point. Thereby the required search area of points reduces.

12.4.2. Additional parameters of automatic measurement of tie points coordinates

For more detailed setup and adjustment and refinement of the basic parameters of tie points coordinates measurement the **Tie point measurement parameters** window of additional parameters is used. It is opened using the **More** button located in the main **Automatic tie point measurement** window.

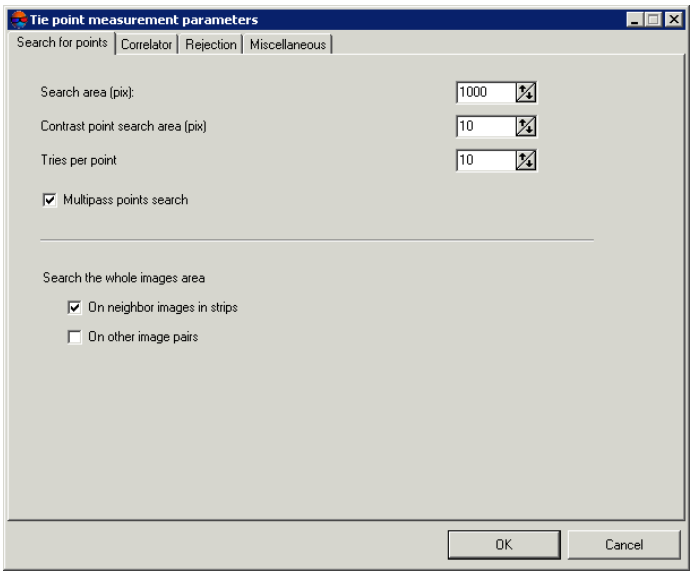


Fig. 23. Parameters of points measurements

The **Tie point measurement parameters** window contains four tabs with parameters.

To reset to default parameters, delete the *ProjCorrMatchOptions.x-ini* file located in the project root folder.

The **Search for points** tab allows to setup the following parameters:

- **Search area** (pix) – allows to specify a “halfsize” of area of matching point search;
- **Contrast point search area** (pix) allows to search tie points in areas with maximal contrast (on images with clear objects outlines);

In some cases it is reasonable to measure points in areas with low contrast, for example, when forested areas have maximal contrast, and in these areas correlator’s errors are very probable. In this case the **Contrast point search area** value should be set to 0.

- **Tries per point** – number of tries of matching point search with correlation coefficient value that exceeds specified in the search area;
- **Multipass points search** [recommended] allows to perform points search and filtering on stereopairs in multiple passes with help of different algorithms. It is applied in case of insufficient quality of the block layout, when real relative rotation of images relative to each other is sufficiently big;

For multipass points search it is recommended to set correlation threshold high enough, for example, 95%.

- **Search the whole images area** allows to specify images pairs to search points: adjacent images in each strip and/or non-adjacent pairs of images in a strip and inter-strip pairs of images.

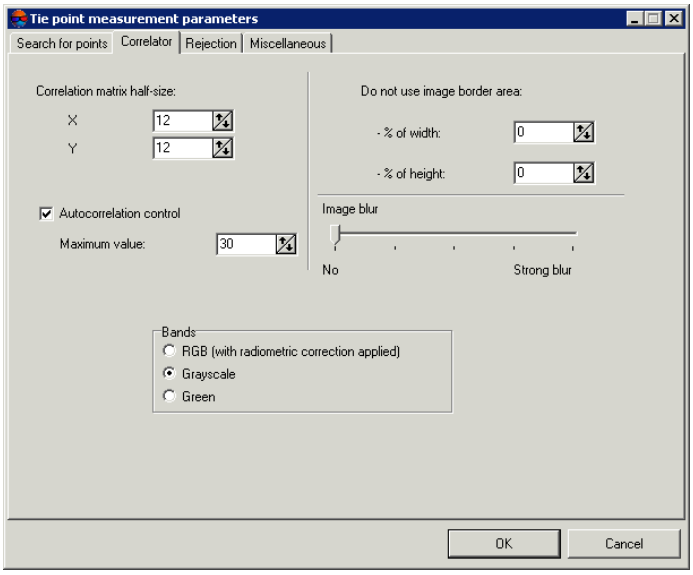


Fig. 24. Parameters of correlator

The **Correlator** tab is used to setup parameters of area correlator work and contains the following parameters:

- **Correlation matrix half size** (pix) allows to specify size of correlation matrix by X and Y axes;

- **Autocorrelation control** allows to specify level of auto-correlation – the **Maximum value** of sigma in Gaussoid that is the top limit of distribution of the mask correlation coefficient in a small area on the same image. The more the sigma value, the less probability of correct points measurement, which were measured using correlation with the given point as an initial one;

- **Do not use image border area** is used to specify a size of area near the image border, that is not used during correlation operation;

  Service area width (2% of image width and height by default) should not be less than on the image; otherwise a big amount of “bad” points would be measured in image service areas.

- the **Image blur** slider is used to consider image material quality, from **No** to **Strong blur**;

  For images without blur or with negligible blur it is *highly not recommended* to place the slider to position different from **No**.

- the **Bands** section allows to choose one of three channels: **Greyscale** (by default), **RGB** and **Green**.

Generally, RGB option is selected for tie point calculation on the color images, passed radiometric correction operation. That allows to enhance measurement accuracy, but increase the work time of automatic calculation.

It is recommended to choose the **Green** option for low quality images acquired by compact digital camera, mounted on UAS, and for images acquired by cameras that use Bayer filter.

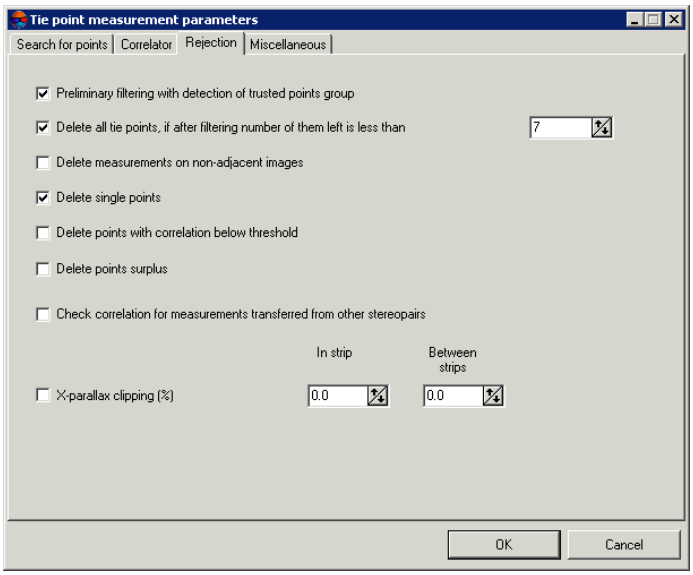


Fig. 25. Filtering parameters

The **Rejection** tab is used to setup filtering parameters of points found and contains the following options:

- **Preliminary filtering with detection of trusted points group** is used to preliminary filtering of blunders, that do not allow calculate correctly angular elements of relative orientation (see the parameters of trusted points group on the **Miscellaneous** tab);

- **Delete all tie points, if after filtering number of them left is less then** specified number – allows to delete *all tie points on a stereopair*, acquired during operation of automatic measurement of points coordinates, if after their filtering their number is not sufficient to perform correct relative orientation;

- **Delete measurements on non-adjacent images** allows to filter potentially erroneous points, measured on non-adjacent images inside a strip;

It is recommended to set the **Delete measurements on non-adjacent images** checkbox on the first step and to not to use this parameter on the second step.

- **Delete single points** allows to reject points measured on single images;

- **Delete points with correlation below threshold** allows to delete points previously measured using correlator, if their correlation coefficient in below threshold value specified in the **Correlation threshold** field of the **Automatic tie point measurement** window;

  It is recommended to use the option for recurrent or final points filtration, since the filtering covers *all* measured points, not only new ones, added during just another start of automatic tie points measurement operation.

- **Delete points surplus** allows to delete points, if their number exceeds number specified in the **Points per stereopair** field of the **Automatic tie point measurement** window, sorted by the Y-parallax in descending order;

  The parameter considers whether the **Filter points by zones** checkbox is marked, that allows to delete points evenly. It is recommended to use the option after the initial tie points measurement on UAS images.

  The points are deleted regardless of type and number of measurements per point (the program may delete both GC point and the points in triple overlap).

- **Check correlation of measurements transferred from other stereopairs** is used to check on each stereopair correlation coefficient of measurements, collected during points transfer from other stereopairs, since the chain of such transfers may lead to errors accumulation and bring unacceptable result;

- **X-parallax clipping** (%) allows to specify number of points with minimal and maximal x-parallax (relatively to total amount of points) which will be deleted after filtering **in strip** and **between strips**.

  It is recommended to apply this rejection method if erroneous points are dispersed clearly along stereopair basis (if, for example, a highway with bright marking goes in parallel to survey basis and correlator puts points on marking line elements, which do not correspond with each other.

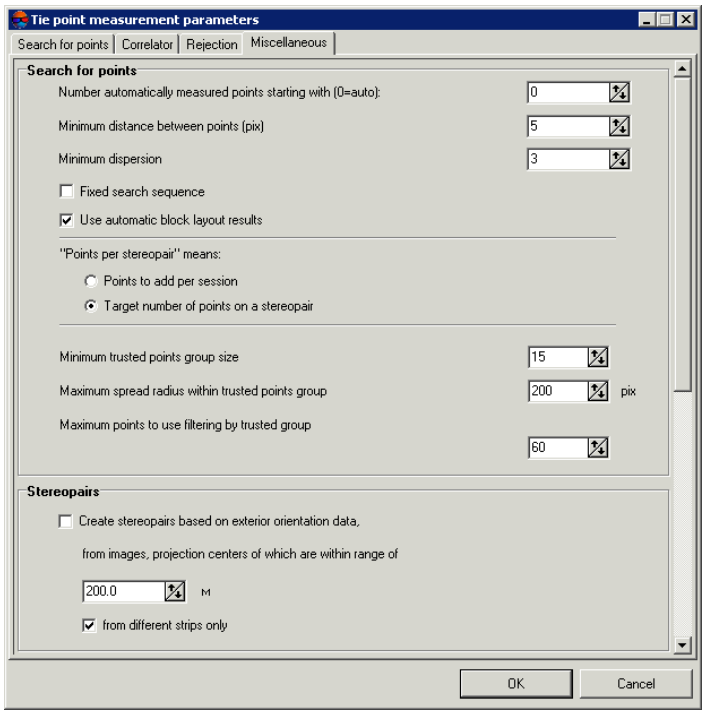


Fig. 26. Miscellaneous parameters

The **Miscellaneous** tab contains sections and options to setup the following additional parameters:

- **Number automatically measured points starting with** is used for automatic numbering of measured tie points starting with number, specified in the entry field, that allows to distinguish these points from the ones already measured on the project images;

  Regardless of the set value, the program does not generate points with duplicate numbers. If the point with some number already exists, then this number will be skipped when creating new points.

- **Minimum distance between points** (pix) allows to specify minimal distance in pixels between points measured on the image;

  It is recommended to increase the value of this parameter, when the problems with block adjustment occur. The parameter is considered only during measurement new points. Existing tie points are not rejected.

- **Minimal dispersion** allows to specify minimal dispersion of mask to protect from points search on the clouds and water bodies;

  The option is used to exclude points in monotonous areas, for example, for spaceborne scanner images, if there are black strips on images borders, and for overexposure due to cloudiness.

- **Fixed search sequence** – allows to obtain the same results of automatic measurement of tie points coordinates during multiple runs of the operation with the same initial parameters;

- **Use automatic block layout results** allows to use the block layout results, created automatically;

  If the automatically generated block layout is available, then during automatic measurement of tie points coordinates information from current block scheme is not used, and the **Search the whole images area** parameter is also ignored. The default search parameters are used only (considering data of automatic block layout).

- **The "Points per stereopair"** parameter influences on the **Points per stereopair** parameters located in the **Automatic tie point measurement** window and allows to select the following number of points:

  - **Points to add per session** – values specified in the main window, that mean a number of *new* points, which will be added to already measured ones;

  - **Target number of points on a stereopair** – values specified in the main window, that define *total* points number;

  The resulting number of measured points may be both greater than a predetermined amount – due to points transfer from adjacent stereopairs, and less due to the subsequent rejection of points. Default value is 30 points on each in-strip images pair, and 10 points – in inter-strip overlap. The minimum number of points to control the vertical parallax residual is 6.

- parameters which allow to specify *trusted points group* to be used as a master sample for points rejection (see the **Preliminary filtering with detection of trusted points group** parameter on the **Rejection** tab). A group of points is considered as trusted if the following two conditions are met during the points search:

  1. The distance between the point on one image and the corresponding point on another image should not exceed the parameter specified in the **Maximum spread radius within trusted points group** input field.

  2. Number of points found, which satisfy to the first condition should not be less than the parameter specified in the **Minimum trusted points group size** input field.

  If a trusted group has been found, it supposedly means that angles of relative orientation have been computed correctly and the points rejection can be performed using these data. Otherwise, the rejection of points will not be executed, even if the **Preliminary filtering with detection of trusted points group** checkbox is set on the **Rejection** tab.

The **Maximum points to use filtering by trusted group** parameter is used to specify the limitation on the number of points to reject.

It is recommended to set the **Maximum points to use filtering by trusted group** value from 40 to 60. It is not recommended to set more than 60 points.

The **Stereopairs** section contains the following parameters:

- **Create stereopairs based on exterior orientation data, from images, projection centers of which are within range of** – if this option is checked, the stereopairs will be composed from images, projection centers of which are located at the distance no more than a specified value (in meters), otherwise, the stereopairs are composed from nearest images in a strip.
- **From different strips only** – if this option is checked, the in-strip stereopairs will not be considered. Otherwise, all in-strip stereopairs will be considered, including the nonadjacent.

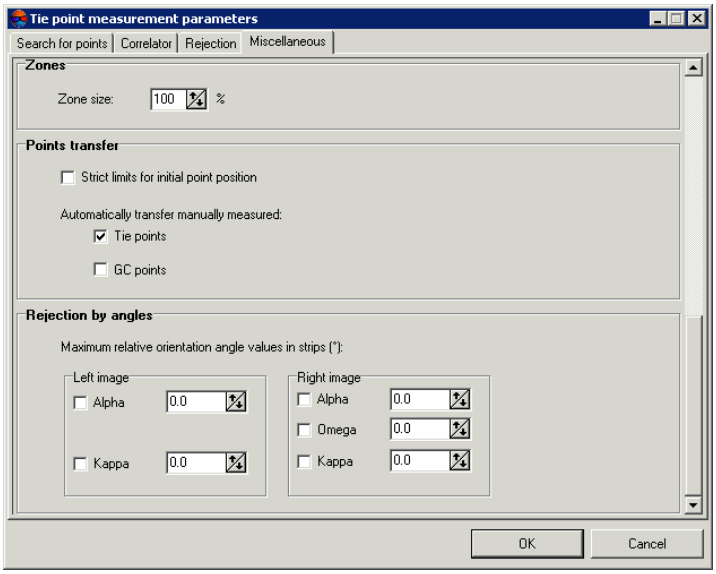


Fig. 27. Miscellaneous parameters

The **Zones** section allows to define a zone size on a stereopair, where the program performs automatic search and measurement of tie points coordinates.

The **Points transfer** section contains the following parameters:

- **Strict limits for initial point position** – if the checkbox is set on, the program performs search for a point *only inside* of image, otherwise, the search is possible out of the image boundary, if the **Search area** parameter value on the **Search for points** tab exceeds the image size.

- **Automatically transfer manually measured** – allows to transfer tie and/or GCP, measured manually.

The **Rejection by angles** section allows to specify parameters of measured points filtering by single or multiple relative orientation parameters of the right or left image.

In some cases after automatic measurement of tie points coordinates due to erroneous points the images are rotated in a block and their relative orientation parameters are calculated incorrectly. To prevent images rotation the filtering of measured tie points by the values of the rotation angle is used. To do this it is necessary to change angles threshold value (in degrees) for each of stereopair elements. As a result, the points which cause exceeding of angles thresholds will be rejected after relative orientation recalculation.

It is not recommended to use this method of rejection for blocks, in which the images can actually be rotated in relation to each other, since in this case the likelihood of removing properly placed tie points increases.

12.5. Relative orientation report

12.5.1. Report parameters and output

The program allows to view the results of relative orientation operation after measurement of tie points coordinates. To view and analyse the data, and control accuracy of relative orientation the program allows to generate a report, that is formed considering specified parameters of accuracy control, residuals threshold and data output format.

Relative orientation and accuracy control includes the following steps:

- accuracy control for measurements on stereopairs using residual vertical parallaxes;
- accuracy control for measurements in triple overlap zones using discrepancies in tie points measurements taken on two adjacent stereopairs (models);
- control of tie points number and uniformity of their distribution on stereopairs and in triplets;
- control of difference between kappa angle and a block scheme.

It is possible to view the relative orientation report in the **Automatic tie point measurement**, **Triangulation points** windows, and in the **Points measurement** module after clicking the button. Prior to the report appearing the **Relative orientation report settings** window opens.

When the report is opened in the **Points measurement** module, the **Relative orientation report settings** window in not opened, and the report is opened only for images opened

in the module considering preset or default parameters. To view and edit the parameters it is possible to use the link in the report window [*Report parameters*].

In order to open the relative orientation report perform the following actions:

1. Choose **Orientation › Relative orientation report** or click the button in the toolbar of the **Triangulation** window. The **Relative orientation report settings** window opens. It is used to specify parameters of accuracy control and format of output results of relative orientation in report.

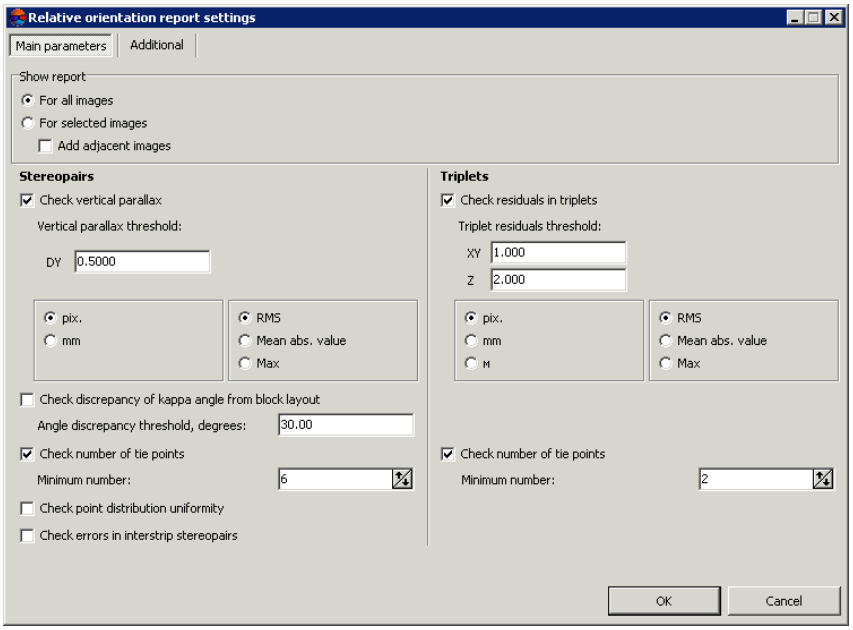


Fig. 28. Parameters of relative orientation report

2. Select the **Main parameters** tab (it is selected by default).

3. In the **Show report** section specify block images to be included to relative orientation report:

   - to view a general report for the whole images block select the **for all images** option;
   - to view a report for *selected* images select the **for selected images** option;
   - to view a report for *selected* and their *adjacent* images select the **for selected images** option and set the **add adjacent images** checkbox.

4. In the **Stereopairs** section specify the following parameters of accuracy control for points measurements on block stereopairs:

- to check measurements for vertical parallax error select the **Check vertical parallax** checkbox and input acceptable threshold value (in pixels or mm) for selected error type (RMS, mean or maximal error);

  It is recommended to set the threshold value of maximal error equal to the pixel size.

- to check discrepancy of kappa angle from block layout set on the **Check discrepancy of kappa angle from block layout** checkbox and specify a threshold value of angles discrepancy in degrees;

  It is recommended to specify **Angle discrepancy threshold** values from 30 to 45 degrees.

- to check stereopairs for sufficient measurements number set the **Check number of tie points** checkbox and specify minimal number of tie points per stereopair;

  It is recommended to specify **Minimal number** value not less than 12 point per in-strip stereopair (2 points per each of 6 standard zones) and at least 2 points per inter-strip stereopair.

- to check distribution uniformity of tie points on stereopairs set on the **Check point distribution uniformity** checkbox;

  There is *non-uniform* points distribution on a stereopair, if in each of 6 standard zones a number of points differs more than 2 times from average amount of points in zone.

- to check number of tie points and their distribution uniformity on inter-strip stereopairs set on the **Check errors in inter-strip stereopairs** checkbox.

  The checkbox is cleared by default, since an analysis of points in 6 standard zones for *inter-strip* stereopair is not necessary in many cases.

5. In the **Triplets** section specify the following parameters of accuracy control for points measurements in triplets:

   - to check measurement errors in triplets set on the **Check residuals in triplets** checkbox and input threshold value by XY and by Z (in pix, mm or meters) for selected residual type (RMS, mean or maximal error);

   - to check triplets for sufficient number of measured tie points set the **Check number of tie points** checkbox and specify minimal number of points.

     It is recommended to specify a **Minimal number** at least 3 points per each triplet.

6. Open the **Additional** tab, that includes sections used to setup data view parameters in the report.

   The **Residuals format** section is used to setup format of errors numeric values in the report:

   - **fixed point** – is used to set format of errors numeric values accurate within 3 decimal places;
   - **exponential** – is used to set format of errors numeric values in exponential notation, where a part of number is replaced with symbols E+n, where E (exponent) means multiplying the preceding number by 10 to the power n.

   The **Precision** section is used to setup output data accuracy, select: **normal**, **high** or **maximal**.

   The **Angles** section is used to setup angles format in the report:

   - **Alpha, omega, kappa** – angular elements of image exterior orientation (are used in Russian coordinate systems);
   - **omega, phi, kappa** – angular elements of image exterior orientation (are used in International coordinate systems (see the “Block adjustment” User Manual)).

   The **Angle units** section is used to setup format of angles measurements units:

   - **radians**;
   - **degrees**;
   - **gons** – plane angle measurement unit that equals to 1/100 of flat right angle measurement unit, and full angle is 400 gons.

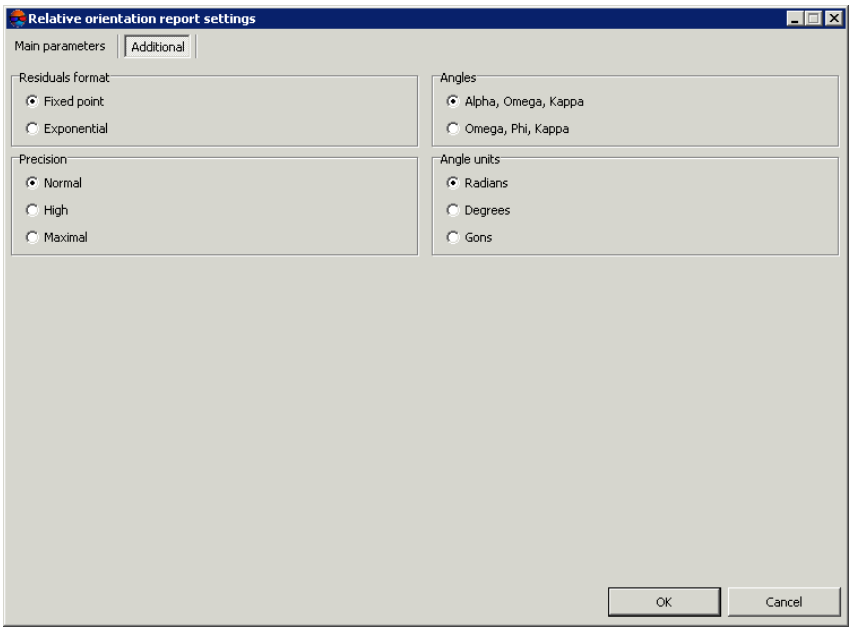


Fig. 29. Additional report parameters

7. Click OK. The report on relative orientation results is opened. It considers all specified main and additional parameters (see the Section 12.5.2).

12.5.2. Report view and analysis

Report on relative orientation includes results of relative orientation operation, displays statistics of tie points measurement, and allows to reveal and eliminate errors of points measurement. The report is generated for all or for selected project images considering parameters specified in the **Relative orientation report settings** window.

A feature of relative orientation report is the ability to pass to the **Points measurement** module directly from the report that allows to eliminate detected measurement errors.

It is possible to view relative orientation report from different windows of the program using the button. Prior to the report appearing the **Relative orientation report settings** window opens.

When the report is opened from the **Points measurement** module, the **Relative orientation report settings** window is not opened, and the report is shown only for images opened in the module considering previously set or default parameters. To view and edit the parameters it is possible to use the link in the report window [*Report parameters*].

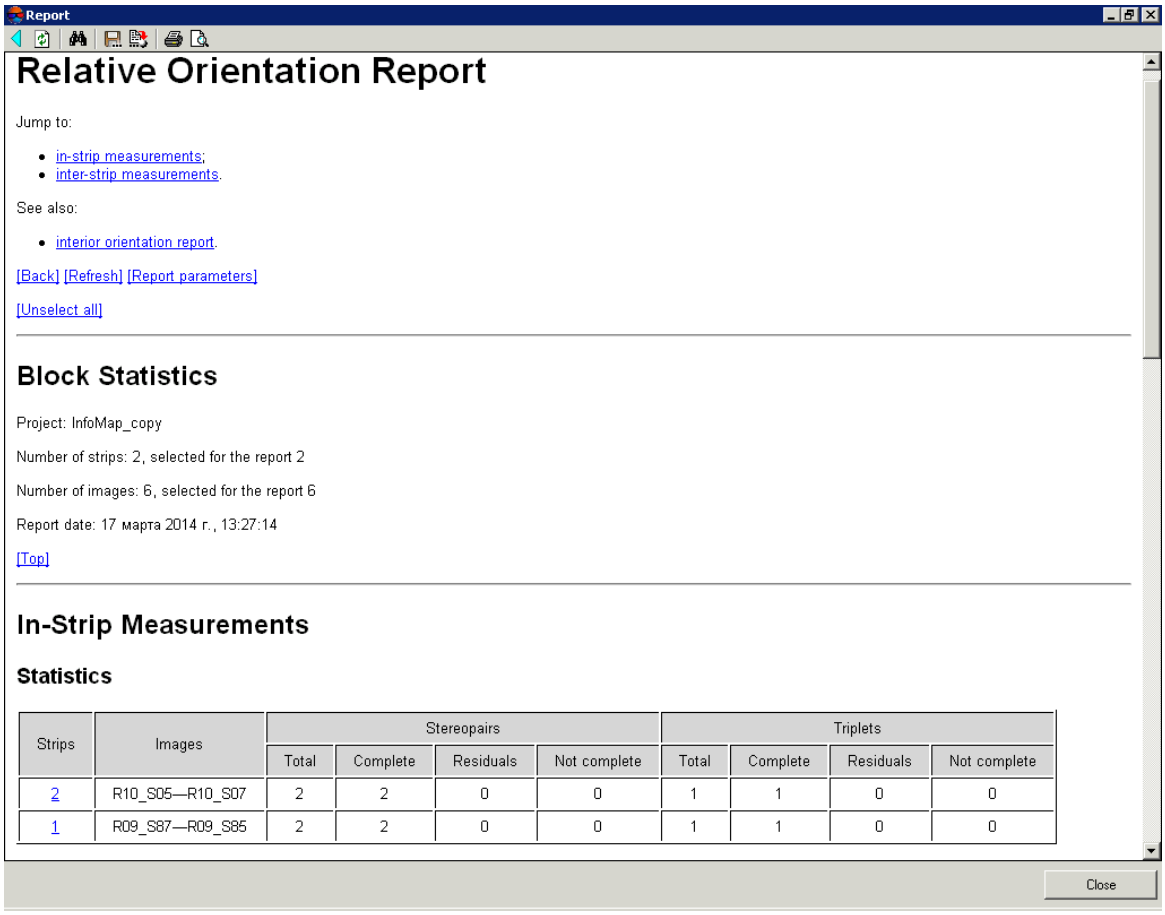


Fig. 30. Relative orientation report

Relative orientation report contains the following main elements and sections:

- the toolbar with buttons used to perform the following operations:
  - – allows to return to previous view of the report;
  - – allows to refresh relative orientation results in the report after editing of tie points in the **Points measurement** module;
  - – allows to perform a search for information in the report;
  - – allows to save report data to files with `*.htm`, `*.html` extensions out of active profile resources;
  - – allows to save report data to files with `*.htm`, `*.html` extensions in active profile resources;
  - – allows to print a report;
  - – allows to open a report preview window before its printing.

- the links in upper part of a report:
  - jump to [*in-strip measurements*] – allows to view the points measurements inside strips;
  - jump to [*inter-strip measurements*] – allows to view the points measurements between strips;
  - see also the [*interior orientation report*] – allows to open report on interior orientation;
  - [*Back*] – allows to go back to previous report view;
  - [*Refresh*] – allows to refresh relative orientation results in the report after tie points editing in the **Points measurement** module;
  - [*Report parameters*] – allows to change the parameters and refresh the report;
  - [*Unselect all*] – allows to cancel data selection in the report;
  - [Top] – allows to go to the report top.
- the **Block statistics** section of a report used to view general statistics, contains the following information:
  - a project name;
  - a total number of project strips/images;
  - a number of selected strips/images;
  - report generating date.
- the **In-strip measurements** section of a report used to view and analyse points measurements inside strips, contains the following tables:
  - statistics table on in-strip measurements (strips table);
  - table of stereopairs of each strip;
  - table of triplets of each strip.

In inter-strip stereopairs and triplets tables there is a possibility to go to the **Points measurement** module and open images of selected stereopair/triplet automatically, that allows to edit points measurements there.

- the **Inter-strip measurements** section of a report used to view and analyse points measurements between strips, contains the following tables:

- statistics table on inter-strip measurements;
- table of inter-strip stereopairs.

In inter-strip stereopairs tables there is a possibility to open selected stereopair in the **Points measurement** module that allows to edit points measurements there.

12.5.3. The in-strip measurements section

The **In-strip measurements** section of report is used to view points measurements results inside a strip and contains the following data:

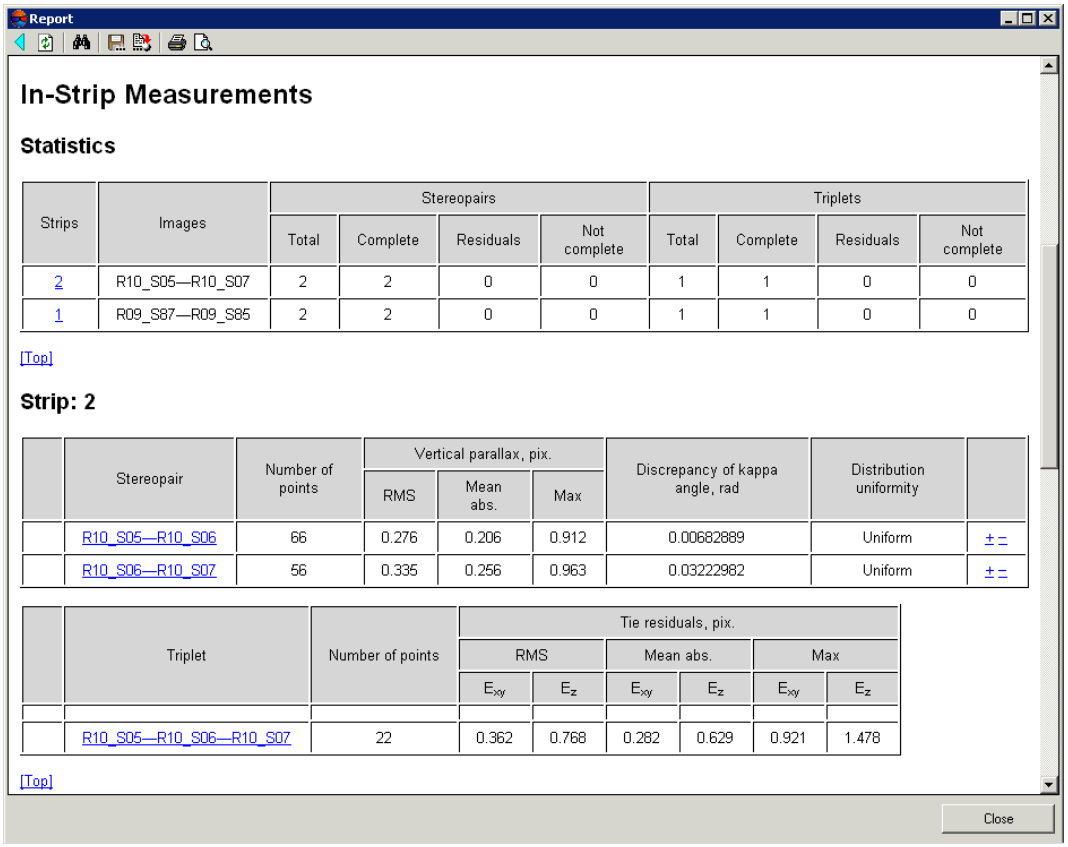


Fig. 31. The “In-strip measurements” section

- *Table of strips* (**Statistics**) contains measurements data inside each strip and includes the following columns:
  - the **Strips** column is used to display a strip name in block;
  - the **Images** column is used to display names of the first and the last images in a strip;
  - the **Total** column is used to display a number of stereopairs/triplets in each strip;

- the **Complete** column is used to display a number of stereopairs/triplets with performed relative orientation with errors within specified thresholds;
- the **Residuals** column is used to display a number of stereopairs/triplets with errors exceeding specified thresholds;
- the **Not complete** column is used to display a number of stereopairs/triplets for which relative orientation is not performed.

Yellow color highlight is used if relative orientation inside a strip is performed with errors.

Strips where there is no relative orientation results are highlighted by red color.

- *Table of stereopairs* contains points measurements data on stereopairs for each strip and includes the following columns:
  - the first column is used for points measurements editing and allows to open the**Points measurement** module with images of stereopair selected in the table;

    When editing is completed and the **Points measurement** module is closed, click the [*Refresh*] link in the report to re-calculate relative orientation and refresh the report.

  - the **Stereopair** column is used to display names of images of each stereopair of a strip;

    Click the stereopair link to open detailed report on measurements of selected stereopair (see the Section 12.5.5).

  - the **Number of points** column is used to display a number of points measured on a stereopair;
  - the **Vertical parallax** column is used to display a value of vertical parallax for all measurements on a stereopair (RMS, mean abs. and maximal error) considering threshold parameters, error type and measurement units specified in the **Relative orientation report settings** window;

    A row of stereopair with points which coordinates failed to be calculated, is highlighted by red color, and in the **Vertical parallax** column the warning message "*Coordinates calculation failed*" is displayed with specifying Y-parallax value in brackets.

  - the **Discrepancy of kappa angle** column is used to display a value of kappa angles difference (calculated using block scheme) between images.
  - the **Distribution uniformity** column is used to display data about uniform or non-uniform distribution of points on a stereopair;

A distribution of points on a stereopair is considered as non-uniform, when in any of 6 standard zones, a number of points differs more than twice from average number of points in zone.

- the **+/-** buttons in the last column allow to highlight/cancel highlight of stereopair on a block scheme in 2D-window for visual estimation of stereopair location in images block.

A stereopair is highlighted along with adding it to already highlighted ones in 2D-window. Cancelling of a stereopair highlighting is performed along with “subtraction” from highlighted stereopairs.

Stereopairs with measurements errors are highlighted by yellow color, stereopairs with unavailable relative orientation by red color.

The following errors are shown by red color (they are depending on parameters specified in the **Relative orientation report settings** window):

- number of points measured on a stereopair, below specified threshold;
- values of vertical parallax, exceeding specified threshold;
- non-uniformity of points distribution;

If there each standard zone contains measurements of coordinates of at least one point, then a stereopair with measurements errors is highlighted by yellow color.

- difference of kappa angles, that exceeds specified value.

- *Table of triplets* displays data on measurements in each triplet of a strip and contains the following columns:
  - The first column is used for measurements editing and allows to open the**Points measurement** module and to open automatically images of selected triplet at the same time;

When editing is completed and the **Points measurement** module is closed, click the [*Refresh*] link in the report to re-calculate relative orientation and refresh the report.

  - the **Triplet** column is used to display names of images of each triplet in a strip;

After clicking the triplet link the detailed report on selected triplet measurements is opened (see the Section 12.5.6).

  - the **Number of points** column is used to display number of points measured on triplet;

- the **Tie residuals** column is used to display values of tie residuals in triplet by XY and Z (RMS, mean abs. and max error) considering parameters of threshold, error type and measurement units specified in the **Relative orientation report settings** window.

Triplet errors by ties, exceeding specified thresholds, are highlight by red color.

12.5.4. The inter-strip measurements section

The **Inter-strip measurements** section of report is used to view points measurements results inside a strip and contains the following data:

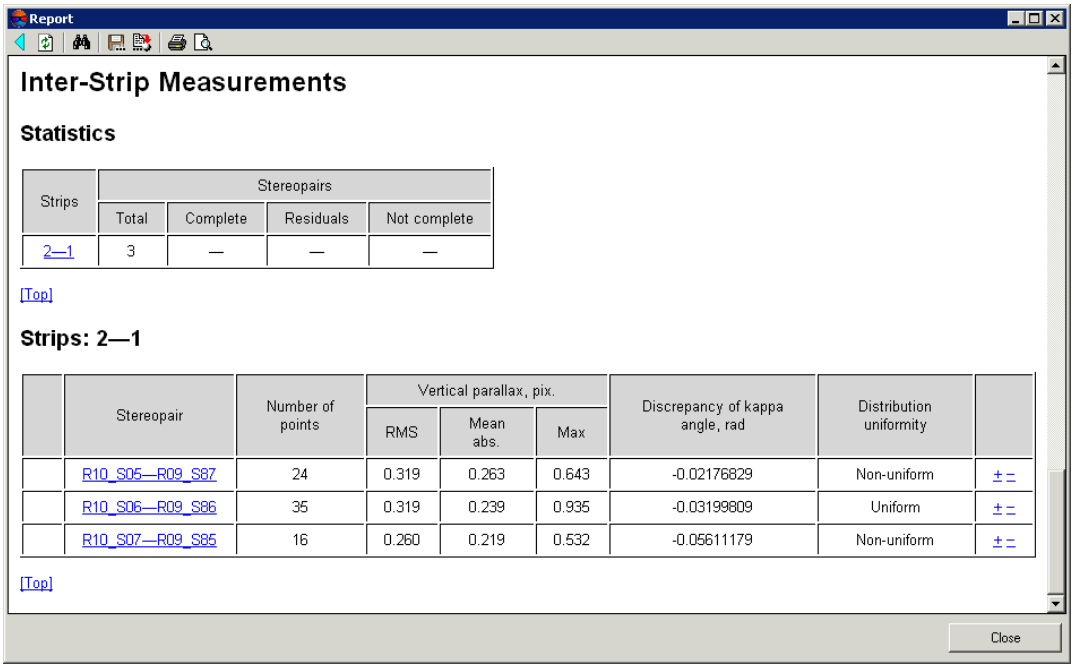


Fig. 32. The “Inter-strip measurements” section

- *The inter-strip ties table* (**Statistics**) displays a number of inter-strip stereopairs for each pair of adjacent strips and presence of measurement errors during relative orientation operation.

- *The inter-strip stereopairs table* contains the following columns:

  - the first column is used to edit points measurements and allows to open the **Points measurement** module and to open automatically at the same time images of inter-strip stereopair selected in the table;

When editing is completed and the **Points measurement** module is closed, click the [*Refresh*] link in the report to re-calculate relative orientation and refresh the report.

- the **Stereopair** column is used to display names of images of each inter-strip stereopair;

  After clicking the inter-strip stereopair link the detailed report on selected stereopair measurements is opened (see the Section 12.5.4).

- the **Number of points** column is used to display a number of points measured on inter-strip stereopair;

- the **Vertical parallax** column is used to display a value of vertical parallax for all measurements on a inter-strip stereopair (RMS, mean abs. and maximal error) considering threshold parameters, error type and measurement units specified in the threshold parameters;

- the **Discrepancy of kappa angle** column is used to display a value of kappa angles difference (calculated using block scheme) between images.

- the **Distribution uniformity** column is used to display data about uniform or non-uniform distribution of points on a inter-strip stereopair.

- the last columns allows to highlight a stereopair (**+**) or cancel the highlighting of a stereopair (**–**) in 2D-window that allows to estimate visually whether the stereopair is located within images block.

  A stereopair is highlighted along with adding it to already highlighted ones in 2D-window. Cancelling of a stereopair highlighting is performed along with “subtraction” from highlighted stereopairs.

If in the **Relative orientation report settings** window the **Check errors in interstrip stereopairs** checkbox is set, then the errors in the report are highlighted in the following way: *yellow* color shows strips and stereopairs that contain points measurements exceeding threshold, and the errors values are shown by *red* color.

12.5.5. The stereopair measurements section

Relative orientation report provides possibility to view a detailed report on any selected stereopair that contains data on tie points measurements, calculated relative orientation parameters, information about kappa angles difference and uniformity of tie points distribution on a stereopair. A detailed report allows to perform control of measurement accuracy of common points of a stereopair images by values of vertical parallax residuals. To view detailed report for selected stereopair click the stereopair hyperlink in the tables of in-strip and inter-strip stereopairs.

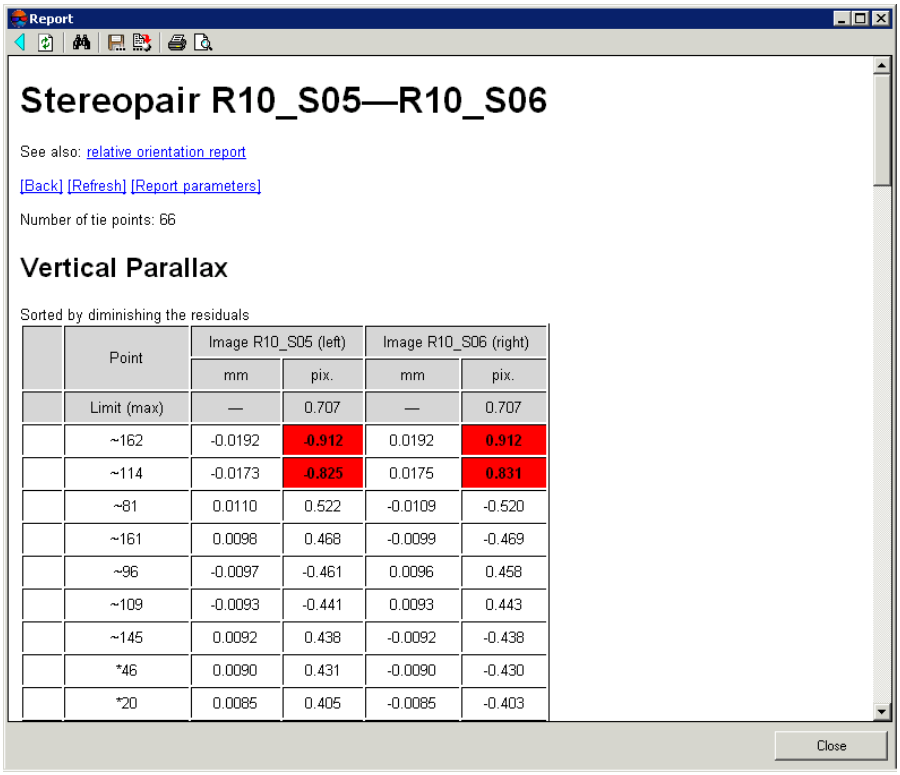


Fig. 33. Detailed report for selected stereopair

Detailed report on selected stereopair includes the following data:

- hyperlinks of detailed report:
  - [*Relative orientation report*] – the link is used to return to the first page of the common report on in-strip and inter-strip measurements;
  - [*Back*] – the link is used to return to previous view of detailed report on stereopair measurements;
  - [*Refresh*] – allows to refresh relative orientation results in the report after tie points editing in the **Points measurement** module;
  - [*Report parameters*] – the link is used to change the report parameters and to refresh the report;
  - [*Edit*] – the link is used to view and edit measurements on a stereopair in the **Points measurement** module;
  - [*Select stereopairs*] – allows to select a stereopair on a block scheme in 2D-window;
  - [*Unselect stereopairs*] – allows to unselect a stereopair on a block scheme in 2D-window;

- [*Unselect all*] – allows to unselect all previously selected stereopairs.

- information about number of measured tie points on a stereopair;

- the *Vertical parallax* table contains the following columns:

  - the first column is used to edit selected tie point and allows to open the **Points measurement** module and to open at the same time images of the stereopair automatically and place marker on selected point;

    After the point editing is completed and the **Points measurement** module is closed click the [*Refresh*] hyperlink in the report to re-calculate relative orientation and refresh the report.

  - the **Point** column displays names of tie points;

  - the **Number of points** column is used to display a number of points measured on inter-strip stereopair;

  - the **Image ... (left)** column displays a value of vertical parallax residual on the left image of stereopair (in mm and pix);

  - the **Image ... (right)** column displays a value of vertical parallax residual on the right image of stereopair (in mm and pix).

  In the *threshold* row the threshold for vertical parallax residual is displayed in accordance with specified value, measurements units and residual type (RMS, Mean abs. and max error) of the **Vertical parallax threshold** parameter in the **Relative orientation report settings** window.

  At the bottom of the table there are final values of vertical parallax residual on all measurements of the stereopair (RMS, Mean abs. and max error). The program performs control of threshold exceeding only for error type specified in the **Relative orientation report settings** window.

  Values of vertical parallax residuals exceeding specified threshold, are highlight by red color.

- the *Relative orientation parameters* table contains values of calculated relative orientation angles for the left and right images according to selected angular system and measured units on the **Additional** tab in the **Relative orientation report settings** window;

- the *Orientation 2D (by block scheme)* and *Discrepancy of kappa angles* tables contain values of kappa angles;

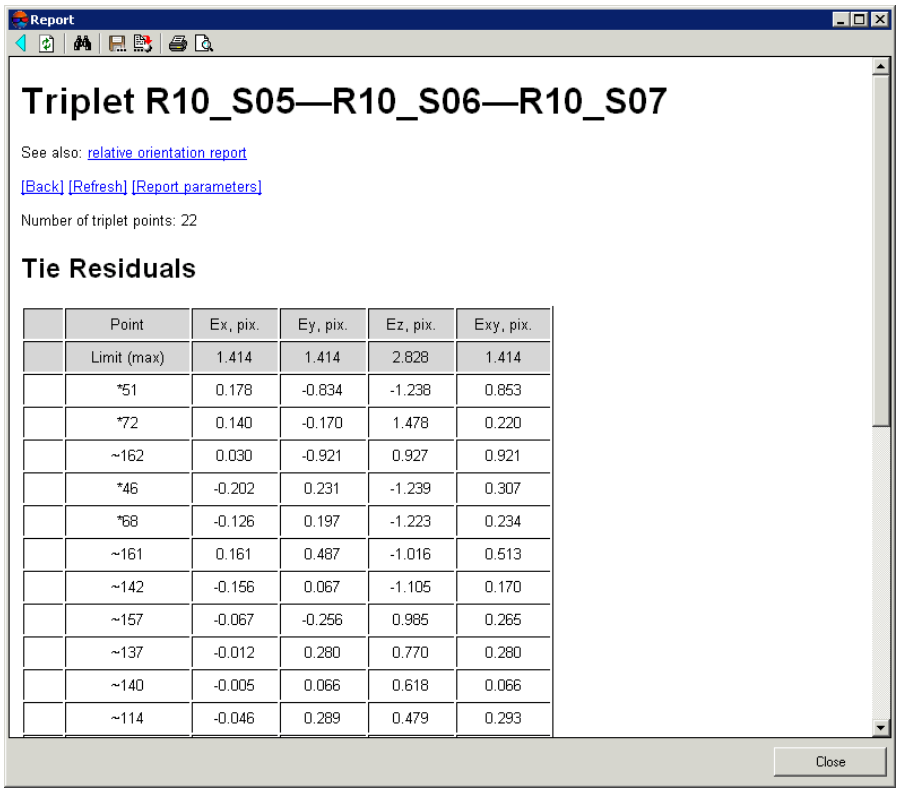
  Accuracy control of kappa angles discrepancy between images is performed if in the **Relative orientation report settings** window the appropriate checkbox is set and a threshold value for kappa angles discrepancy is specified.

- the *Distribution uniformity* tables contain information about uniformity of points distribution over standard zones. To estimate the parameter the system analyses a difference of points number in each of 6 standard zones.

Control of points number and uniformity of their distribution on stereopair's zones is performed if corresponding parameters are specified in the **Relative orientation report settings** window.

12.5.6. The triplet measurements section

Relative orientation report provides possibility to view a detailed report on selected triplet. A detailed report for a triplet is used to view and perform accuracy control of measurements in triplet by tie points errors. In order to view a detailed report on selected triplet click the triplet link in the *triplets table* of the **Inter-strip measurements** section of the report (see the Section 12.5.3).



	Point	Ex, pix.	Ey, pix.	Ez, pix.	Exy, pix.
	Limit (max)	1.414	1.414	2.828	1.414
	*51	0.178	-0.834	-1.238	0.853
	*72	0.140	-0.170	1.478	0.220
	~162	0.030	-0.921	0.927	0.921
	*46	-0.202	0.231	-1.239	0.307
	*68	-0.126	0.197	-1.223	0.234
	~161	0.161	0.487	-1.016	0.513
	~142	-0.156	0.067	-1.105	0.170
	~157	-0.067	-0.256	0.985	0.265
	~137	-0.012	0.280	0.770	0.280
	~140	-0.005	0.066	0.618	0.066
	~114	-0.046	0.289	0.479	0.293

Fig. 34. Detailed report for selected triplet

Detailed report on selected triplet includes the following data:

- hyperlinks of detailed report:
  - [*Relative orientation report*] – the link is used to return to the first page of common report on relative orientation;

- [*Back*] – the link is used to return to previous view of detailed report on measurements in triplet;
- [*Refresh*] – allows to refresh relative orientation results in the report after tie points editing in the **Points measurement** module;
- [*Report parameters*] – the link is used to change the report parameters and to refresh the report;
- [*Edit*] – the link is used to view and edit a triplet measurements in the **Points measurement** module;
- [*Stereopairs*] – two links used to proceed to detailed measurements report of points on stereopairs, that form the triplet (see the Section 12.5.5).

- information about number of measured tie points in a triplet;
- the *Tie residuals* table contain the following columns:
  - the first column is used to edit selected tie point and allows to open the **Points measurement** module and to open automatically at the same time triplet images and to place marker on selected point;

    After the point editing is completed and the **Points measurement** module is closed click the [*Refresh*] hyperlink in the report to re-calculate relative orientation and refresh the report.

  - the **Point** column is used to display a tie point name;
  - the **Ex**, **Ey**, **Ez**, **Exy** columns – tie residuals by X, Y, Z axes and tie residual by (XY) in measurement units specified for residuals control in triplet in the **Relative orientation report settings** window.

  In the *threshold* row there is a triplet residual threshold according to specified value, measurement units and error type (RMS, Mean abs. and max error) of the **Triplet residuals threshold** parameter in the **Relative orientation report settings** window.

  At the bottom of the table final values of tie residuals *on all triplet measurements* are shown (RMS, Mean abs. and max error). Accuracy control is performed only for the residual type that is specified for the **Triplet residuals threshold** parameter in the **Relative orientation report settings** window.

  Values of tie errors that exceed specified threshold are highlighted by red color.

13. Block adjustment

13.1. Preliminary block adjustment

In order to adjust images block perform the following actions:

1. Click the button of the main toolbar to refresh initial block scheme (to refine block layout) using measured tie and GC points.

   See a description of block layout creation in the "Aerial triangulation" User Manual.

2. Choose **Orientation › Block adjustment** or click the button on the main toolbar. The **adjustment** toolbar opens.

   See detailed description of interior orientation step in the "Aerial triangulation" User Manual.

3. Click the button **Settings** on the **Adjustment** toolbar. The **Settings** window opens.

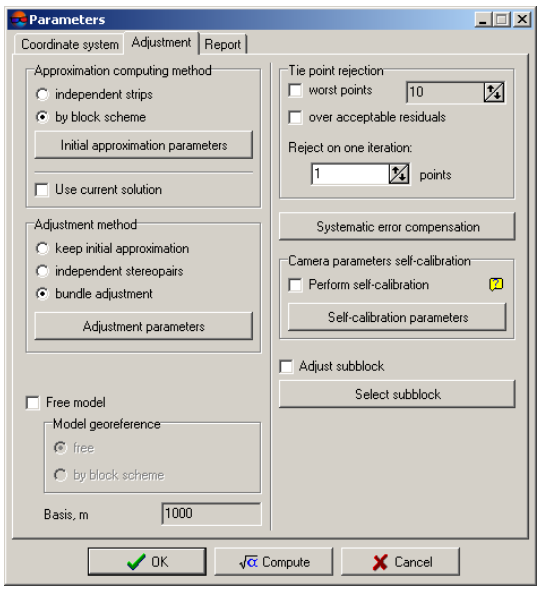


Fig. 35. Adjustment parameters for the first adjustment operation

4. On the **Adjustment** tab define the following parameters *for the first* start of the adjustment procedure:

   1. Choose the **by block scheme** option in the **Approximation computing method** section.

2. Click the **Initial approximation parameters** button. The **Initial approximation parameters** window opens.
3. Set the **Use ground control points coordinates** and **Use projection centers coordinates** checkboxes.
4. Click OK.
5. Choose the **bundle adjustment** option in the **Adjustment method** section.
6. Click the **Adjustment parameters** button. The **Bundle adjustment parameters** window opens.
7. Set the **Use ground control points coordinates** and **Use projection centers coordinates** checkboxes.
8. Choose the **in 3D space** option in the **Minimize residuals** section.
9. Click OK to return for the **Parameters** window.

5. Click **Compute** to start the adjustment operation.
6. To analyse the adjustment results you can use visual control of residuals on block scheme and the **Residuals** window which contains brief residuals report.
7. Pick out adjustment parameters, analyse and eliminate residuals to obtain satisfying adjustment result.

After making any alterations to points measurements data it is necessary to re-start the adjustment procedure once again.

To use previous adjustment results for the new adjustment operation, set the **Use current solution** checkbox on the **Adjustment** tab of the **Parameters** window.

8. It is recommended to use self-calibration of camera parameters during adjustment procedure, if camera without calibration was used.

13.2. Using self-calibration

[optional] If a complete set of camera parameters is unavailable, use self-calibration of camera parameters during adjustment procedure.

Self-calibration of camera parameters – is automatic calculation of camera parameters (corrections to principal point coordinates and focal length, distortion coefficients) during adjustment operation.

To use self-calibration of camera parameters during adjustment operation perform the following actions:

1. Set on the **Perform self-calibration** checkbox and click the **Self-calibration parameters** button on the **Adjustment** tab of the **Parameters** window. The **Camera parameters self-calibration** window opens.

   See detailed description of self-calibration operation in the "Block adjustment" User Manual.

2. Choose camera to be calibrated in the **Cameras** table. In the **Coefficients** table define initial values of camera parameters in the **Initial value** column and choose parameters for optimization in the **Optimize** column.

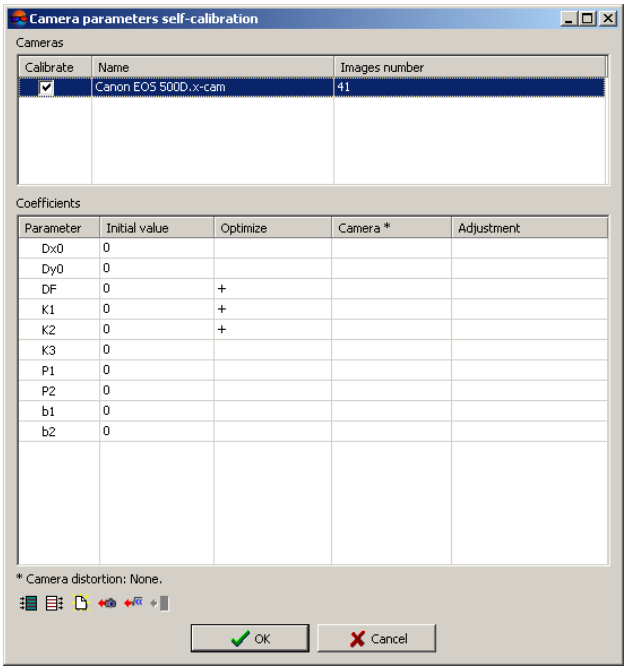


Fig. 36. Self-calibration of camera parameters

3. Click OK. Setup adjustment parameters in the **Parameters** window and click the **Compute** button to start the adjustment procedure.

4. When the adjustment procedure is completed estimate the adjustment accuracy and results of camera self-calibration shown in the **Adjustment** column of the **Camera parameters self-calibration** window. If you are satisfied with the results pass to step # 5, otherwise, change initial values of parameters and/or set of parameters for optimization and adjust the block once more.

5. Click the **Save** button to save the adjustment results.

6. Choose **Orientation › Manage cameras**. The **Manage project cameras** window opens.

7. In the **Project cameras** list select new calibrated camera (cameras) `[autocal].x-cam` and assign it (them) to project images. Click the **Execute** button. Click OK.

   See a description of the **Manage project cameras** window in the "Aerial triangulation" User Manual.

8. Choose **Orientation › Interior orientation › Calculate interior orientation**.

9. Choose **Orientation › Block adjustment** or click the button on the main toolbar. Click the button **Settings** on the **Adjustment** toolbar. Block will be adjusted considering new results of interior orientation.

13.3. Brief residuals report

The program allows to display brief residuals report, which contains RMS errors, mean absolute and maximal adjustment errors.

Brief residuals report is used for quick estimation of adjustment results without viewing detailed report.

In order to display brief residuals report, click the button on the **Adjustment** toolbar. The **Residuals** window opens.

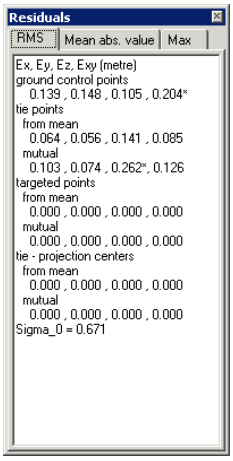


Fig. 37. The "Residuals" window

In the Stereopairs mode brief report contains information about mean absolute errors on GCP and check points (in meters), about tie and targeted points, as well as about tie residuals on projection centers (*mutual* and *from mean* residuals).

If adjustment is performed by bundle adjustment procedure, the `Sigma_0` value is calculated.

The Sigma_0 value shows how much adjustment discrepancies correspond to specified thresholds on points coordinates measurements and input GCP data (GCP and projection centers coordinates). If the thresholds were specified correctly, the Sigma_0 has value close to 1 (±30%).

If the Sigma_0 is much greater than 1, there are errors in points coordinates measurements, in input GCP data or because of incorrectly specified thresholds on points coordinates measurements. If the Sigma_0 is mush less than 1, the threshold on points coordinates measurements were specified incorrectly or there are some other errors (see Section 13.4).

13.4. Creating adjustment report

The program provides possibility to view full statistics of adjustment, summary information about adjustment residuals and control data.

To display adjustment report the button on the **Adjustment** toolbar.

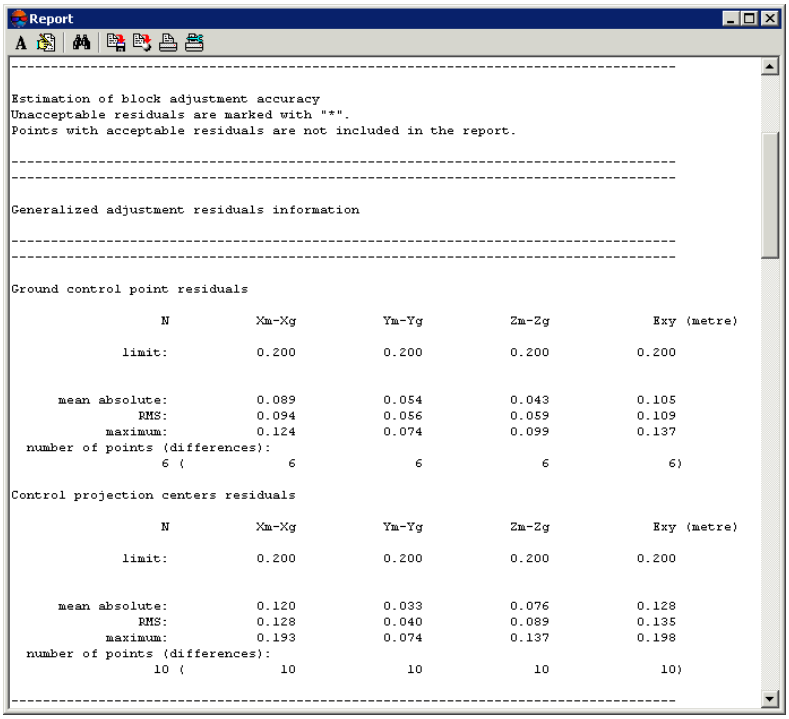

Report
Estimation of block adjustment accuracy
Unacceptable residuals are marked with "*".
Points with acceptable residuals are not included in the report.
Generalized adjustment residuals information
Ground control point residuals
N Xm-Xg Ym-Yg Zm-Zg Exy (metre)
limit: 0.200 0.200 0.200 0.200
mean absolute: 0.089 0.054 0.043 0.105
RMS: 0.094 0.056 0.059 0.109
maximum: 0.124 0.074 0.099 0.137
number of points (differences):
6 (6 6 6 6)
Control projection centers residuals
N Xm-Xg Ym-Yg Zm-Zg Exy (metre)
limit: 0.200 0.200 0.200 0.200
mean absolute: 0.120 0.033 0.076 0.128
RMS: 0.128 0.040 0.089 0.135
maximum: 0.193 0.074 0.137 0.198
number of points (differences):
10 (10 10 10 10)

Fig. 38. The window of adjustment report

The toolbox of the **Report** window contains the following buttons:

- – allows to edit a font of report text;
- – allows to edit (make changes) a report (**F4**);
- – allows to start search in report's text (**Ctrl+F**, **Ctrl+G** and **F3**);
- – allows to save a report into text file;

The report also saves in the *backup* project folder automatically with the adjustment results (only for central projection images).

- – allows to save a report into program resources;
- – allows to print a report;
- – allows to setup report printing parameters.

The adjustment report displays the following values:

- residual values calculated on GCP, check, tie points, and projection centers for the whole block and for each point;
- catalogue of points coordinates;
- images exterior orientation parameters;
- GPS corrections;
- corrections for exterior orientation parameters.

Report content is setup on the **Report** tab of the **Parameters** window.

Residuals and errors are displayed in the report as follows:

- *X, Y, Z* – coordinates values taken from model (from strip when using *independent strips method*, from stereopair when using *independent stereopairs method*);
- *X1, X2, Y1, Y2, Z1, Z2* – values of points coordinates on two different models;
- *Xcp, Ycp, Zcp* – values of points coordinates, averaged over all models;
- *Xg, Yg, Zg* – geodetic value of points coordinates, specified by the user for GCP and check points;
- *Exy, Ez* – average residuals of points XY and Z coordinates;
- *dX, dY, dZ, dS* – discrepancies on GCP;
- *dX, dY, dZ, dXY* – GPS corrections on projection centers.

13.5. Adjustment accuracy control

It is recommended to perform control of block adjustment accuracy after the completion of the adjustment operation. The adjustment results are displayed in graphic form as a

residuals vectors in the Stereopairs and Images modes of working windows, numeric values of residuals are included to adjustment report.

If the adjustment brought unsatisfactory results and there some blunders the program provides possibility to improve the results using editing of points position. To do this it is necessary “re-measure” points, on which the residuals vectors exceed defined threshold and are shown by red color.

The program provides two ways of points position editing:

- by change of points geodetic coordinates;
- by change of points position.

In order to change geodetic coordinates of points on image perform the following actions:

1. Select a point on a block scheme or in a list, which error exceeds specified threshold value.
2. Click the button. The **Points attributes** window opens.
3. [optional] In order to display the editor panel set the **Editing panel** checkbox in the **Information** window.
4. Click the **Coordinates** button. The **Point coordinates** window opens. For GCP and check points the **X**, **Y**, **Z**, **all** checkboxes are set, and coordinates and accuracy values (standard deviation) of these coordinates in meters are displayed in corresponding fields.

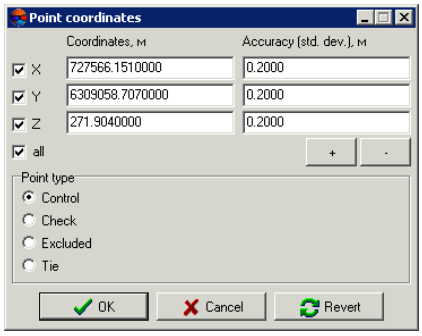


Fig. 39. Changing geodetic coordinates of selected GCP

5. [optional] To change the value of the **Accuracy** parameter use the + or − button.
6. To change a type of selected point set a type in the **Point type** section.

If the **Tie** type is specified for GCP or check point, its geodetic coordinates will be deleted.

7. Input necessary coordinates to the **X**, **Y**, **Z** input fields or clear one or multiple checkboxes to use a point as a XY or Z.

When working with a scanner images it is possible to use only XYZ GCP, that is why if for the GCP one of the **X**, **Y**, **Z** checkboxes is cleared, the point is used as a tie point and its coordinates are not considered during adjustment. If such points are available in a project, the program shows warning message during adjustment.

8. [optional] Click the **Revert** button to restore initial points coordinates.

9. Click OK. After that the geodetic coordinates of point will be changed.

In order to change point's position on image perform the following actions:

1. Select a point on a block scheme or in a list, which error exceeds specified threshold value.

2. Click the button. The Object attributes window opens.

3. Click the **Measure** button. The **Points measurement** window opens.

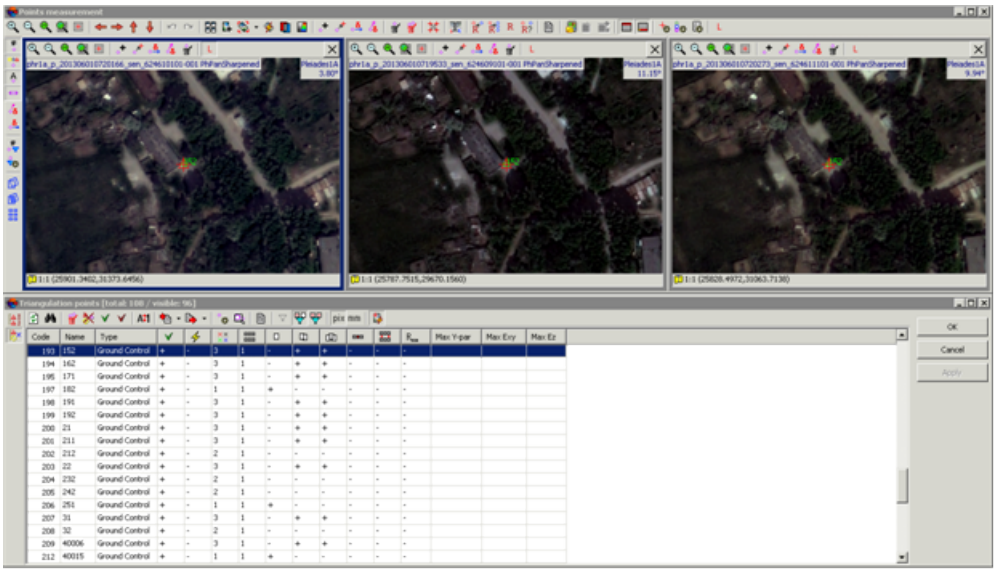


Fig. 40. Editing of selected point

4. Move a point manually or using correlator (see description of correlator work in the "Aerial triangulation" User Manual).

5. Click OK. The **Points measurement** is closed as a result.

6. Click **Compute** to complete changing point's position on image.

In order to use interstrip points and points non-transferred in some strip in the adjustment by *independent strips method* or *independent stereopairs method*, it is necessary to measure coordinates of the points on adjacent images inside the strip during aerial triangulation or in the **Points measurement** window (see the “Aerial triangulation” User Manual).

14. Distributed Processing

14.1. General Information

Program includes capability of distributed processing of some tasks. This helps achieve maximum utilization of hardware resources for carrying out large projects.

Distributed tasks processing is a capability of parallel task execution with multiple processor cores or multiple computers in local network.

The program provides an opportunity only local distributed processing with using several cores of one computer.

Computers participating in the distributed processing are assigned the three following modes:

- *Server* is the control center of the distributed processing, responsible for distribution of tasks and synchronization of *Client* computers;
- *Client* is a computer, which receives tasks to process from the *Server*;

  Each *Client* must be connected to the *Server.*

- *Monitor* is a computer, where the distributed processing control center is launched and the **Monitor for distributed processing** window is opened to observe task processing.

To launch the **Distributed processing control center** perform one of the following:

- in context menu of System Monitor modulechoose the **Distributed processing control center**;

  The **Start automatically** menu item allows to launch the distributed processing control center automatically concurrently with launching any module of program when System Monitor module is also launched.

- choose the **Service › Distributed processing › Control centre**.

The distributed processing control center is launched with properties of previous working session of program in the Windows system tray the icon displays. During the first launch the **Distributed processing setup** window is also opens.

The distributed processing icon in the Windows system tray is different depending on using computer in the distributed processing mode:

- – *Server* and *Client* are not launched (computer is not used in distributed processing);
- – *Server* connection fault;
- – only *Server* is launched;
- – *Server* and *Client* are launched;
- – only *Client* is launched, connection to *Server*.

14.2. Workflow of distributed processing

The following work flow is used to distributed tasks processing:

1. Launch the **Distributed processing control center**.
2. Choose the computer as a *Server* and *Client* of distributed processing.
3. Choose not-used **Port for incoming connections**.
4. Setup parameters of distributed processing task and click OK. The list of distributed processing task is created and displayed in the **Tasks** table.
5. Open the **Monitor for distributed processing**.
6. Choose the task for processing in the **Task** section.
7. Choose the computer as a Client to process chosen task in the **Computers** section.
8. [optional] Click the button to perform all distributed processing task automatically.
9. Click the button on the **Tasks** section toolbox to start distributed processing.

Each next task start with lagged on some seconds.

14.3. Distributed processing parameters setup

The **Distributed processing setup** window is used to setup distributed processing parameters.

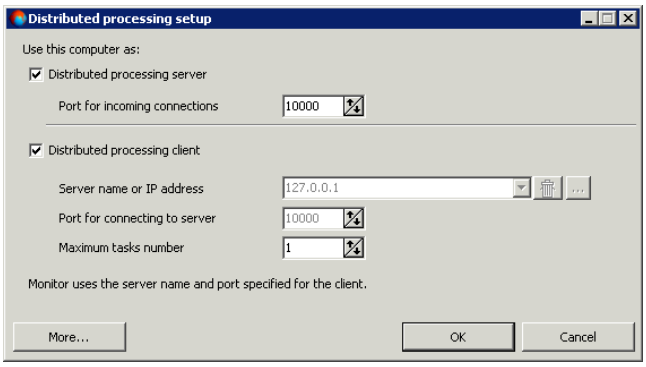


Fig. 41. Distributed processing parameters setup

The program provides an opportunity only to use local computer for distributed processing tasks with using several cores of one computer, i.e. using computer as a *Server* and *Client* at the same time.

Perform the following actions to do this:

1. Set on the **Distributed processing server** checkbox.
2. Set free port in the **Port for incoming connections** field.

   If not possible to connect with chosen port, choose another one.

3. Set on the **Distributed processing client** checkbox. Server name and port number are set automatically.
4. [optional] Set on the **Maximal number of tasks**, which are process of each *Client* at the same time. By default the value is equal to number of cores or processors of computer.
5. Click OK. During the first setup the **Monitor of distributed processing** window opens and in the Windows system tray the icon of distributed processing is displayed.

   It is necessary to restart the distributed processing control center if parameters were changed.

Also there is an opportunity to detail setup of distributed processing parameters. Click the **More** button of the **Distributed processing setup** window to do that.

It is strongly not recommended to change default parameters in the e **Distributed processing setup** window.

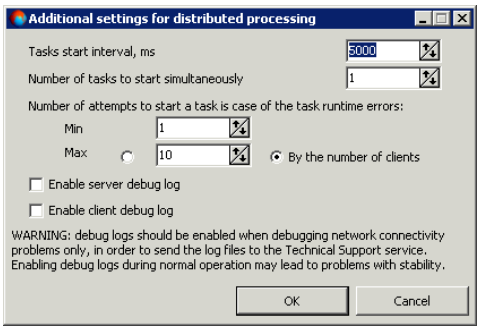

Additional settings for distributed processing
Tasks start interval, ms
5000
Number of tasks to start simultaneously
1
Number of attempts to start a task is case of the task runtime errors:
Min
1
Max
10
By the number of clients
Enable server debug log
Enable client debug log
WARNING: debug logs should be enabled when debugging network connectivity problems only, in order to send the log files to the Technical Support service. Enabling debug logs during normal operation may lead to problems with stability.
OK
Cancel

Fig. 42. Additional distributed processing parameters

The following parameters are available to setup:

- **Task start interval, ms** – allows to change the delay time between starting tasks;
- **Number of task to start simultaneously** – allows to change the number of tasks which are processing in the same time by distributed processing clients;
- **Number of attempts to start in case of the task runtime errors** – allows to change number of attempts ta start the task if there is an error;

  It is reccommended to change the value in case of non-stable network or breaks in electricity supply, etc.

  - **Min\max** – range of restart attemps;
  - **by number of clients** – by default the restart attemps number is equal to number of connected distributed processing *Clients*.
- **Enable server/client debug log** – allows to create a log-file with information about distributed processing (to sent files in technical support during solving problems of Server/Client connection only).

  Set on the **Enable server/client debug log** checkboxes may cause to reducing stability of program's work.

  It is strongly not recommended to set on the **Enable server/client debug log** checkboxes.

14.4. Distributed processing management

The **Monitor of distributed processing** window is used for condition monitoring of distributed processing. The window opens automatically after setup distributed processing parameters.

Also the menu item **Start monitor** of context menu of the distributed processing icon and the **Service › Distributed processing › Monitor** menu items.

While the **Monitor of distributed processing** window opens, the *Monitor* status adds to computer also.

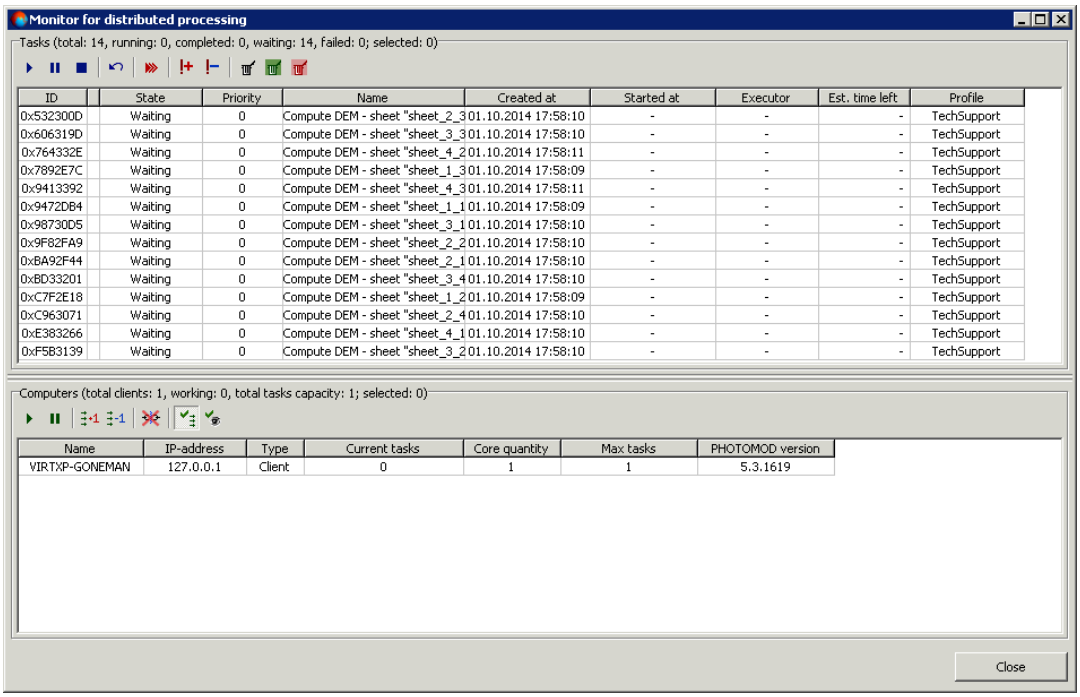

Monitor for distributed processing
Tasks (total: 14, running: 0, completed: 0, waiting: 14, failed: 0; selected: 0)
ID State Priority Name Created at Started at Executor Est. time left Profile
0x532300D Waiting 0 Compute DEM - sheet "sheet_2_3 01.10.2014 17:58:10 - - - TechSupport
0x606319D Waiting 0 Compute DEM - sheet "sheet_3_3 01.10.2014 17:58:10 - - - TechSupport
0x764332E Waiting 0 Compute DEM - sheet "sheet_4_2 01.10.2014 17:58:11 - - - TechSupport
0x7892E7C Waiting 0 Compute DEM - sheet "sheet_1_3 01.10.2014 17:58:09 - - - TechSupport
0x9413392 Waiting 0 Compute DEM - sheet "sheet_4_3 01.10.2014 17:58:11 - - - TechSupport
0x9472DB4 Waiting 0 Compute DEM - sheet "sheet_1_1 01.10.2014 17:58:09 - - - TechSupport
0x98730D5 Waiting 0 Compute DEM - sheet "sheet_3_1 01.10.2014 17:58:10 - - - TechSupport
0x9F82FA9 Waiting 0 Compute DEM - sheet "sheet_2_2 01.10.2014 17:58:10 - - - TechSupport
0xBA92F44 Waiting 0 Compute DEM - sheet "sheet_2_1 01.10.2014 17:58:10 - - - TechSupport
0xBD33201 Waiting 0 Compute DEM - sheet "sheet_3_4 01.10.2014 17:58:10 - - - TechSupport
0xC7F2E18 Waiting 0 Compute DEM - sheet "sheet_1_2 01.10.2014 17:58:09 - - - TechSupport
0xC963071 Waiting 0 Compute DEM - sheet "sheet_2_4 01.10.2014 17:58:10 - - - TechSupport
0xE383266 Waiting 0 Compute DEM - sheet "sheet_4_1 01.10.2014 17:58:10 - - - TechSupport
0xF5B3139 Waiting 0 Compute DEM - sheet "sheet_3_2 01.10.2014 17:58:10 - - - TechSupport
Computers (total clients: 1, working: 0, total tasks capacity: 1; selected: 0)
Name IP-address Type Current tasks Core quantity Max tasks PHOTOMOD version
VIRTXP-GONEMAN 127.0.0.1 Client 0 1 1 5.3.1619
Close

Fig. 43. Monitor for distributed processing

In the **Monitor of distributed processing** window displays information about tasks queue and *Clients* computers using. The window also allows to manage tasks processing.

The window refresh automatically each several seconds.

The **Tasks** containts toolbar and table with information about tasks. The table consists of columns with following information:

- **ID** – unique identifier for each task;
- **State** – the status of the task:
  - `waiting`;
  - `paused`;
  - `performed` – in this case shows the percentage of task completion;
  - `complete`;
  - `failed` – displayed in case of complete part or resource connection error (marks yellow);

  - `not complete` (marks red) – displayed in case of tasks didn't complete because of *Client* was disconnected during the task processing, *Server* was disconnected or task was cancelled.

- **Priority** – priority of the tasks (integer, the larger the number, the higher the priority, the tasks of higher priority are performed in the first place);
- **Name** – type of task and number in tasks list;
- **Created at** – the date and time of posting task;
- **Started at** – the data and time are displayed for started task;
- **Executor** – for started task – the name of *Client* computer, which executes it;
- **Est. time left** – the approximate time before complete processing tasks
- **Profile** – active Client profile at the time of posting of tasks. This profile must be network and connected to other Clients in order that they have been able to execute the tasks.

Points sorting in columns of the list is performed by mouse click on the column header.

If during the task execution an error occurs on any of network computers, it's highlighted in yellow in the list. In this case attempts will be made to perform the same tasks on other computers. The task will remain in the queue with a **Failed** state until it is deleted manually, if no computer in network is able to execute this task.

Table 6. The Tasks section toolbar

buttons	Function
	allows to start selected tasks sequentially
	allows to pause selected tasks
	allows to stop selected tasks
	allows to reset selected tasks state (the **Waiting** caption appears in the **State** field)
	allows to set on the auto run tasks – automatic distribution of tasks in the queue (according to priority) between the Clients and launch of the tasks
	allows to increase priority of selected tasks by 1
	allows to decrease priority of selected tasks by 1
	allows to remove selected tasks from the queue
	allows to remove complete tasks from the queue
	allows to clear the queue of tasks

The **Computers** section contains the table of computers, which are currently in the network and configured with the same *Server*.

The table contains following parameters for each computer:

Points sorting in columns of the list is performed by mouse click on the column header.

- **Name** – shows network computer name;
- **IP-address** – IP-address of the computer;
- **Type** – *Client* or *Monitor;*
- **Current tasks** – tasks number of distributed processing, which currently performed by Client;
- **Core quantity** – the total quantity of Client CPU's cores;
- **Max tasks** – the maximum quantity of simultaneously running tasks specified during the *Client* configuration;

Maximum quantity of tasks are less than or equal to the number of CPU's cores of computer.

- **PHOTOMOD version** – the PHOTOMOD build number for control of compatibility.

It is recommended to use the same RHOTOMOD build on all computers working with the same Synchronization folder.

In the case if the computer is disconnected from the distributed processing, it's highlighted in red in the table.

To perform actions with multiple computers, select them in the table using **Shift** and **Ctrl keys**.

Table 7. The Computers section toolbar

buttons	Function
	allow selected computers to execute new tasks (if forbidden)
	forbid selected computer to execute new tasks When current task complete, *Client* go to sleep mode and doesn't start new tasks temporary
	increase maximum number of simultaneously running tasks by 1
	decrease maximum number of simultaneously running tasks by 1

buttons	Function
	hide disconnected computers (highlighted in red)
	display all connected and disconnected *Client* computers in the table
	display all connected and disconnected *Monitor* computers in the table

15. Additional features

15.1. Automatic block layout creation

The program provides possibility to create block layout for UAS projects automatically.

In order to create a block layout automatically, perform the following actions:

1. Perform preliminary creation of a block layout – **by exterior orientation**, for instance. Perform visual estimation of the block layout, by comparing it with real location of images in a block.

2. Choose **Block › Block layout › Automatic block layout...**. The **Automatic block layout** window opens.

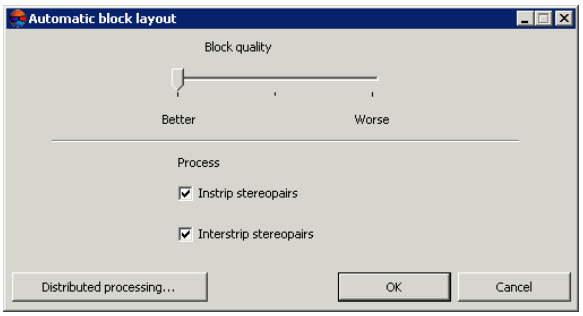


Fig. 44. Parameters of automatic block layout creation

3. Set the **Block quality** using the appropriate slider.

   If there are project images with a rotation angles up to 10 degrees, move the slider to the **Better** side.

   If there are project images with a rotation angles from 10 to 60 degrees, move the slider to the **Worse** side. This increases the likelihood of incorrect data.

4. [optional] Both **Instrip** and **Interstrip stereopairs** are processed in the program by default. Clear one of the checkboxes to exclude appropriate stereopairs from processing.

5. [optional] In order to use distributed processing during automatic creation of block layout, perform the following actions:

    1. Change settings and run the distributed processing server/client (see the "*Distributed processing*" chapter in the "General information about system" User Manual).

    2. Click the **Distributed processing** button. The **Automatic block layout** window opens.

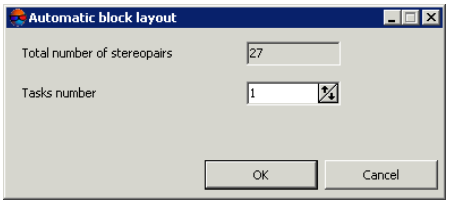


Fig. 45. Parameters of distributed processing of automatic block layout creation

    3. Specify **Tasks number**, which are processed by one computer. See the description of distributed processing setup in the General information User Manual.

It is recommended to specify not more than one task per computer.

Both **Instrip** and **Interstrip stereopairs** are used during distributed processing, regardless of settings.

    4. Click OK. Distributed processing tasks are created and the program shows a message about number of created tasks.

6. Click OK. After that the program will measure tie points created artificially specially to consider them for adjustment (coordinates of the points are not saved). Creation results are saved to *ImageTransforms.x-ini* file in the project resources.

File with results of automatic block layout creation is used for automatic measurement of tie points.

If the operation of automatic block layout creation was interrupted, its results will be also saved in the program.

15.2. Creating overlap map

For visual analysis of images and strips overlap in a block the program provides a feature of overlap map creating. After creating of such a map the overlap areas are created as kind of vector polygons on a new vector layer.

Perform the following actions to create overlap map:

1. Choose **Block › Create overlap map**. The **Create “heat map”** window opens.

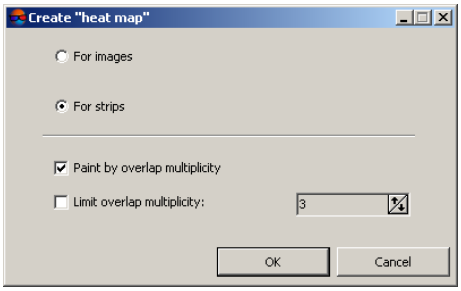


Fig. 46. Parameters of overlap map creating

2. Choose elements of a block to be used for overlap map creating: **For images** or **For strips**.

3. [optional] Set on the **Paint by overlap multiplicity** checkbox to color overlap areas depending on overlap multiplicity, i.e. on number of images/strips that fall into the overlap. When the option is disabled overlap areas are not colored.

4. [optional] Set on the **Limit overlap multiplicity** checkbox and input number of images/strips in overlap area, and when the value will be exceeded the fill color will be not changed.

5. Click OK. A new vector layer containing overlap map is created.

In order to obtain information about number of images that fall to chosen overlap area, allocate a part of overlap map and choose the **Window › Objects attributes**. You can export overlap map using the **Vectors › Export** menu item to choose export format.

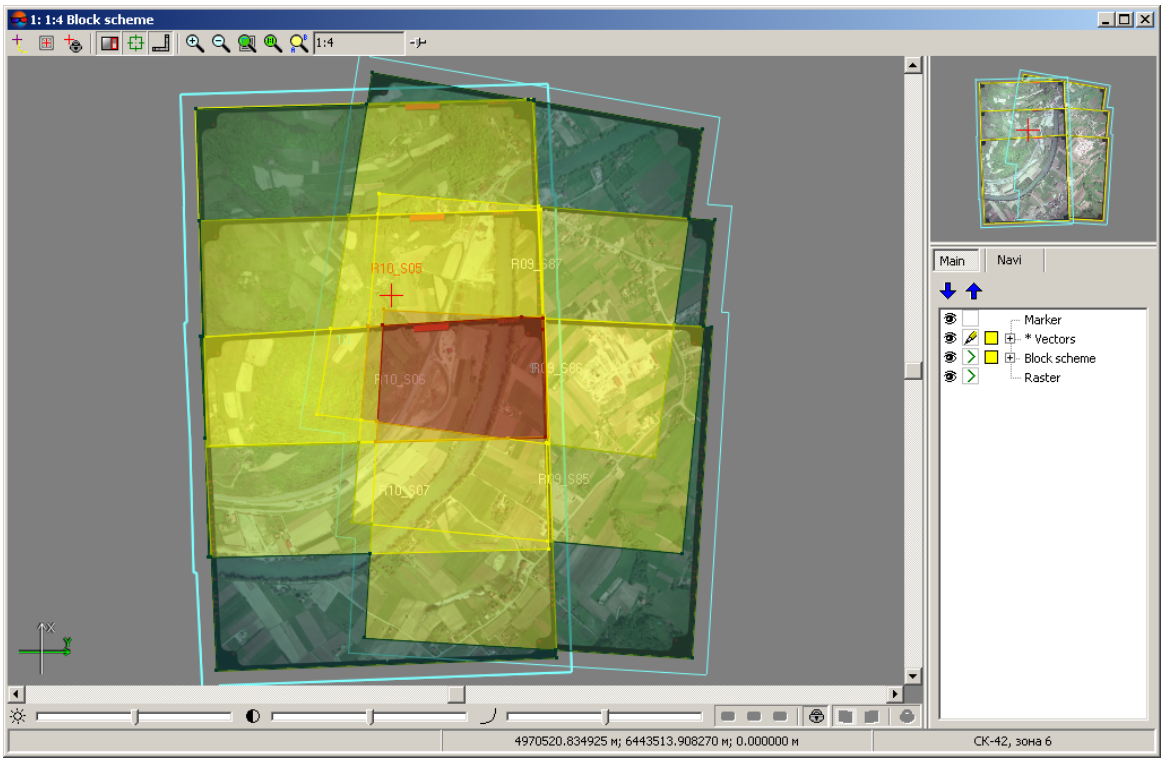


Fig. 47. Overlap map

15.3. Deleting images selectively

The program allows to delete images selectively using specified selection criteria. Perform the following actions to do this:

If images were removed from project, the do not remove from the Windows file system.

1. Choose **Block › Delete images selectively...**. The **Selective delete images** window opens.

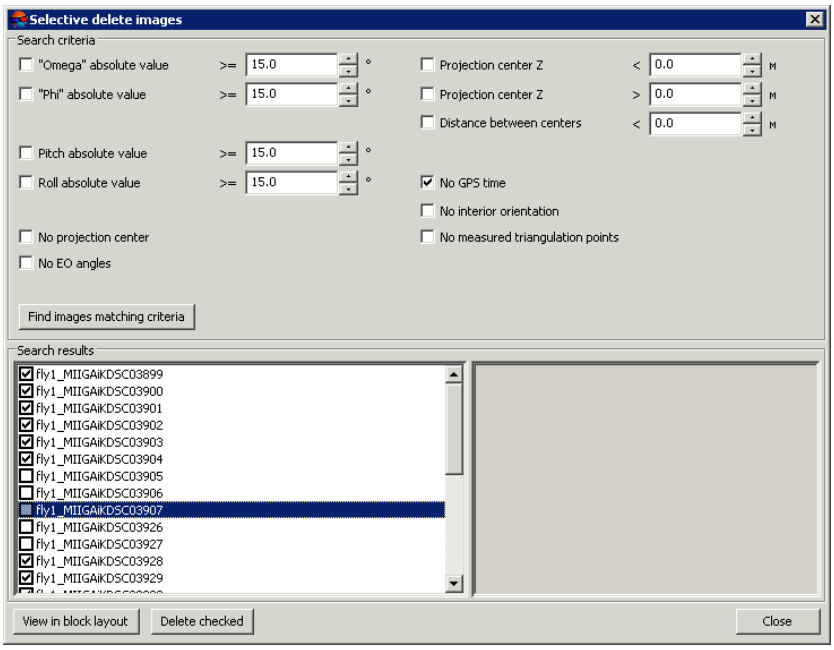


Fig. 48. Setting of images selection criteria for deleting

2. Set on one or more checkboxes to search images by chosen parameters:

   - to search images with omega, phi or pitch/roll angles absolute values greater than specified value (in degrees), set on the **“Omega” absolute value**, **“Phi” absolute value**, **Pitch absolute value** and **Roll absolute value** checkboxes accordingly;

   - to search images where not specified projection centers and/or not specified exterior orientation angles set on the **No projection center** ot **No EO angles** checkboxes;

   - to search images with projection center hight more or less specified value (in meters), set on the **Projection center Z <** or **Projection center Z >** accordingly;

   - to search images with **Distance between centers** in strip less than specified value, set on the appropriate checkbox;

   - set on the appropriate checkboxes to search images with **No GPS time**, **No interior orientation** or **No measured triangulation points**.

3. Click the **Find images matching criteria** button. Images found are shown in the **Search results** list.

4. [optional] To cancel deleting image set of the checkbox near to image name in the **Search results** section.

5. [optional] Click the **View in block layout** button to analyse images selection using block layout. Images selected in the **Search results** list are highlighted in the block layout.

6. Click the **Delete checked** button to delete images selected in the list.

16. Project processing

16.1. Grid creation

The program provides possibility of regular *grid* creation with specified step. A grid step is used as a frequency of nodes creation, in which vicinity spatial coordinates are calculated and pickets are created.

The grid could be created both for the whole images block and for any part of a block or for selected stereopair. A shape of grid borders could be rectangular or as arbitrary polygon.

To create a grid select **Grid › Create** (**Ctrl+N, G**) or click the button button on the main toolbar. After that a new layer *Grid* is created in the*Manager*.

Area of grid creation is determined in one of the following ways:

- in order to create a grid with specified *rectangular border*, press and hold the **Shift** key, and drag by mouse a rectangular area over images block or over selected stereopair;

- in order to create a grid with *arbitrary border*, define a grid creation area in group selection mode by polygon and while holding pressed the **Shift** key, specify by mouse all nodes of boundary of a grid creation area. Complete creation of arbitrary grid border by mouse double click.

- to use vector layer polygons as areas of grid creation, perform the following actions:

  1. Select **Vectors › Create layer** to create vector layer without classifier or load layer with polygons which could be used as a grid boundaries.

  2. Create a polygon in such a way that its boundary coincides with boundaries of area which is used for grid creation.

  3. [optional] Select polygons to be used as boundaries for a grid creation, otherwise, a grid will be created considering all polygons of the layer.

  4. Select **Grid › Create boundaries from vectors**. After that created grid boundary coincides with outline of created polygon.

- to create a grid for the whole images block without defining its boundaries, select **Grid › Properties**, specify its parameters and click OK. Grid is created automatically for the entire block and the grid boundary passes over external boundary of block images.

When a grid boundary is defined the program creates a grid of nodes with specified or default parameters.

In order to change parameters of created grid, select **Grid › Properties**. The **Grid properties** window opens.

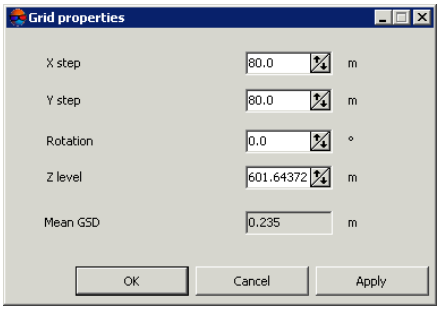


Fig. 49. Regular grid parameters

The **Grid properties** window allows to setup the following parameters:

- **X step** and **Y step** – steps for nodes creation correspondingly by X and Y axes in meters;
- **Rotation** – angle of nodes grid rotation in degrees;

Should be specified for manual work in the pathway mode.

At that, the nodes **grid only** is rotated. Area of nodes grid creation remains in initial position.

- **Z level** – a grid elevation above relief level (in meters) for visual correct display of the grid;
- **Ground sample distance (GSD)** – shows a value of average pixel size in meters, if a project contains adjustment results or pixel size is specified for at least one image.

To display a grid with specified parameters click the **Apply** button. To change parameters click OK.

To save created grid in active profile resources use **Grid › Save** and **Grid › Save as** menu items. The grid is saved to the `*.x-grid` file.

To open existing grid, select **Grid › Open**. To close a grid, select **Grid › Close**.

Context menu of the *Grid* layer in the *Manager* duplicates save and load commands in the **Grid** menu, and allows to close a grid layer.

16.2. Pickets automatic calculating

16.2.1. Automatic calculating of pickets

The program provides possibility to calculate pickets automatically using correlator in overlap areas of stereopair images by regular nodes grid.

Because of large processing data volumes in UAS projects, it is recommended to use automatic calculating of pickets.

All selected stereopairs should be located on adjusted part of a block (see "Block adjustment" User Manual), otherwise, pickets calculation is not performed or is performed incorrectly. In the first case the system displays error message, in the second one – it is not possible to match calculated pickets to project coordinate system.

Acquired pickets are used as a vector base for DEM generation. Additional possibilities of pickets editing allow to obtain vector base for TIN creation and DEM generation.

The principle of automatic pickets calculation is as follows. For each selected oriented stereopair the system performs automatic pass of all grid nodes, located in overlap area of stereopair images, and tries to calculate spatial coordinates in vicinity of each grid node using correlator. In case of successful correlation the system performs accuracy control of each found point's coordinates, and after that the point is either added to vector layer as point object, or is excluded. If the system fails to calculate spatial coordinates in vicinity of some grid node, the node is skipped and the system passes to the next node.

Prior to start of automatic pickets calculation perform the following preparatory actions:

1. [optional] Define *search area*: select block stereopairs where to perform automatic pickets calculation.

2. Create regular nodes grid for selected *search area*.

3. Choose **Vectors › Compute points automatically** or click the button on the main toolbar. The **Compute points** window opens.

If a grid not was not created, it is created automatically for the entire images block and the **Grid properties** window opens, that allows to specify grid parameters.

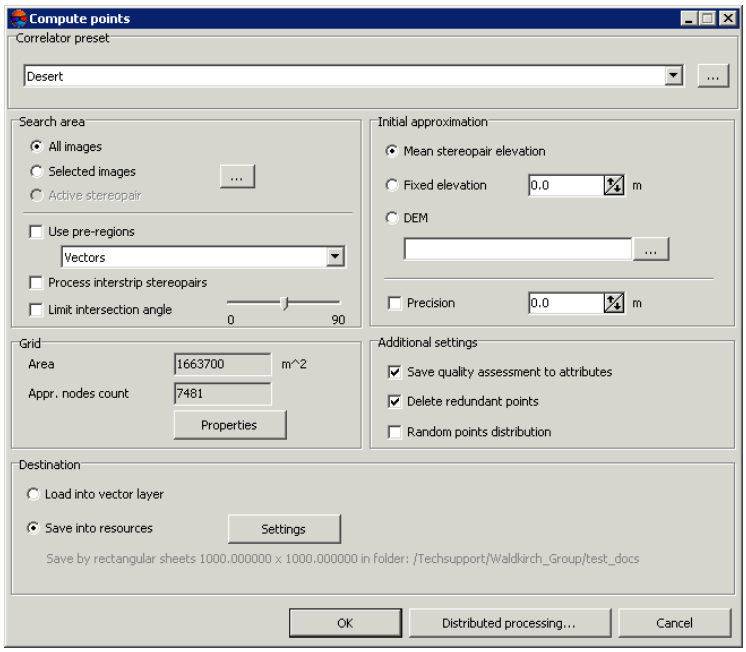


Fig. 50. The “Compute points” window

4. In the **Correlator preset** section select in the list one of the following types of terrain:

Correlator configuration – is a script of pickets calculation operation, that defined a number of passes of regular grid nodes and a set of correlator parameters for each pass.

- *mountainous terrain* – for automatic pickets calculation on images with mainly mountainous terrain with big elevation differences;
- *urban areas* – for automatic pickets calculation on images with mainly urban type of build-up;
- *desert* – for automatic pickets calculation on images with monotonously deserted terrain with rare vegetation;
- *rural area* – for automatic pickets calculation on images with rural areas with with minor amounts of buildings and infrastructure;
- *rural area 2* – for automatic pickets calculation for “rural” area with heterogeneous parts of relief. If there are images with big intersection angle the configuration uses a mask of larger size. Accuracy of pickets calculation is less then when using rural area type.

To view and edit parameters values and to setup *correlator configuration* the list, to create new or delete configurations from the list click the ... button.

5. In the **Search area** section specify a search area, which will be used for automatic pickets calculation:

   - **All images** – allows to select all images of a block;
   - **Selected images** – allows to select block images highlighted in 2D-window;

   To view and change a set of highlighted images in block 2D-window click the ... button.

   - **Active stereopair** – allows to select images of a stereopair opened in active 2D-window.

   All selected stereopairs should be located on adjusted part of a block (see "Block adjustment" User Manual), otherwise, pickets calculation is not performed or is performed incorrectly. In the first case the system displays error message, in the second one – it is not possible to match calculated pickets to project coordinate system.

6. [optional] Pickets calculation is performed by default for strip stereopairs. To calculate pickets for inter-strip stereopairs, formed by selected images set the **Process inter-strip stereopairs** checkbox on.

7. [optional] To filter blunders by Z on images with intersection angle of small or null value, set the **Limit intersection angle** checkbox on and define a value of minimal angle using the slider.

8. [optional] In the **Grid** section the **Area** of the grid layer in m^2, as well as **Appr. nodes count** in a grid are displayed in appropriate fields. To change a grid layer parameters click the **Properties** button.

   To change grid boundaries it is necessary to close the **Compute points** window.

9. In the **Initial approximation** section specify initial value of Z coordinate of a grid node for correlator work:

   Initial approximation defines a value of Z coordinate of grid node, that is used to calculate initial coordinates of picket on the left and right images of a stereopair.

   - **Mean stereopair elevation** – mean elevation of each stereopair, calculated using exterior orientation parameters, is used as initial approximation;
   - **Fixed elevation** – input elevation value in meters to be used as initial approximation;
   - **DEM** – a value of elevation of selected DEM in point with XY coordinates of grid node is used as initial approximation.

If grid node falls into null cell of DEM, the system uses average elevation of corresponding stereopair. To select DEM in active profile resources click the ... button.

To specify value of acceptable deviation of Z-coordinate of calculated pickets from initial approximation set the **Precision** checkbox on and input value of acceptable deviation in meters to the input field.

If the **Precision** checkbox is off, acceptable deviation is calculated automatically according to selected configuration of correlator.

10. [optional] To thin nearest pickets, acquired during passing the same grid nodes on different stereopairs, the **Delete redundant points** checkbox is on in the system by default.

Thinning is performed after completion of pickets calculation operation according to specified radius value, set by used correlator configuration.

When the **Save quality assessment to attributes** checkbox is on, points with minimal correlation coefficient (minimal value of "*corr*" attribute) are removed from several found nearest points.

11. [optional] To distribute pickets randomly in area of halfsize of grid cell from grid node, set the **Random points distribution** checkbox on.

12. In the **Destination** section define parameters of loading and saving of calculated pickets:

- **Load into vector layer** – allows to load pickets into active vector layer;

If there is no active vector layer, pickets are loaded to a new vector layer.

- **Save into resources** – allows to save pickets into active profile resources without loading. Click the **Settings** button to specify parameters of pickets saving. The **Settings for saving points** window opens.

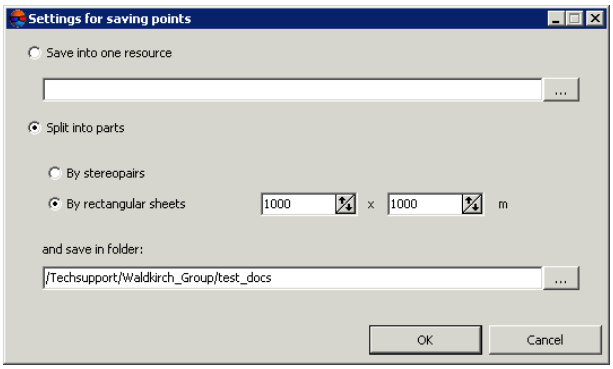


Fig. 51. The “Settings for saving points” window

To save pickets in one vector file of active profile perform the following actions:

1. Select the **Save into one resource** option and click the ... button. The **Save** window opens.

2. Select a folder in the active profile resources and input a name of vector file in the **Resource name** field. Click OK to create a new vector file and to return to the **Settings for saving points** window.

3. The input field of the **Settings for saving points** window shows path and name of new vector file. Click OK to return to the **Compute points** window.

To save pickets in parts into several vector files of active profile perform the following actions:

1. Choose the **Split into parts** option.

2. Select one of the ways of pickets splitting – **By rectangular sheets** and input a size of rectangular area in meters or **By stereopairs**.

3. Input path to save file to the **Save in folder** field or click the ... button, to select name and path in active profile resources to save pickets in parts to corresponding vector files and click OK.

4. The input field of the **Settings for saving points** window shows path and name of new vector file. Click OK to return to the **Compute points** window.

13. Click OK. The pickets calculation operation starts.

In some cases operation of automatic pickets calculation takes a lot of time.

To setup pickets calculation in distributed mode click the **Distributed processing…** button and specify parameters of tasks distribution.

16.2.2. Pickets calculation in distributed processing mode

To calculate pickets in distributed processing mode, perform the following actions:

1. Change settings and run the distributed processing server/client.

2. Choose **Vectors › Compute points automatically** or click the button on the main toolbar. The **Compute points** window opens.

   If a grid not was not created, it is created automatically for the entire images block and the **Grid properties** window opens, that allows to specify grid parameters.

3. Setup parameters of automatic pickets calculation.

4. Click the **Distributed processing** button. The **Compute points Distributed Processing** window opens.

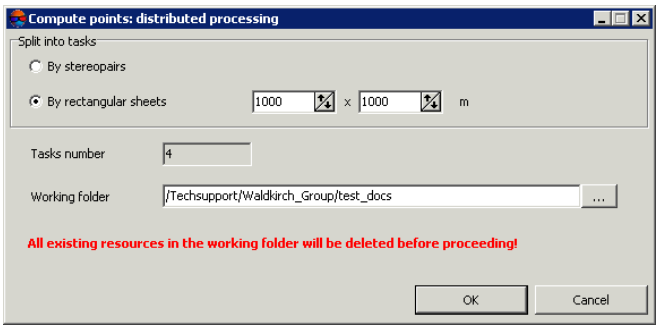


Fig. 52. Parameters of distributed processing of pickets calculation

5. In the **Split into tasks** section select a way of splitting of processing operation into tasks:

   - **By stereopairs** – allows to process each stereopair in a separate task;

     Since tasks are executed independently from each other, the system doesn't remove points, falling into the same grid nodes from different stereopairs (for example, during filtering of nearest points).

   - **By rectangular sheets** – it is necessary to specify in the fields a size of rectangles, into which the entire search area is split (in meters). Filtering of nearest pickets is not performed in this case. The result of each task processing is saved to the file with name like `Sheet_X_Y.x-data`.

     Rectangle, circumscribing grid boundaries in project coordinates system, is split by rectangular sheets of a size specified in the fields. Each sheet includes images parts from all stereopairs, into which it falls.

If stereopairs are processed in separate tasks, after that it is necessary to perform manual data correction. Calculated pickets are saved in resources, named by stereopairs names.

The **Tasks number** field displays calculated number of tasks depending on selected way of workflow split and/or size of specified areas.

It is not possible to define number of tasks manually.

6. In the **Working folder** section click the ... button and select **empty** folder in active profile resources to save output DEM.

Before operation is performed all data from selected folder is removed. It is strongly not recommended to specify a project folder as a working folder, especially when there are no saved project backups.

7. Click OK. Distributed processing tasks are created and the system shows a message about number of created tasks.

When using distributed pickets calculation, the result of each task is saved to separate file with `tsk` extension in specified **Working folder** of a project.

16.3. Points filtering

The system provides deletion, correction or recognizing pickets which have fallen on buildings, trees, cars, in pits during automatic pickets calculation, and during filtering of accident surges. For that filter of buildings and vegetation id used. After its work only pickets that describe terrain relief are remain in the system.

In this document all points not lying on the relief surface (average smoothed terrain surface), are called *surges*.

Filter of buildings and vegetation allows to apply step-by-step points filtering using particular script, i.e. to apply pickets filtering in multiple passes with different parameter sets.

It is possible to develop customized script of filter workflow or to use default script. Creating script of buildings and vegetation filtering means specifying of passes set, order of their passing and setup the parameters for each pass.

Step-by-step filtering allows to achieve optimal results of objects filtering on any type of terrain to acquire pickets, that correctly describe terrain relief, and that could be used to generate high quality DEM.

By default, the system uses standard script that includes three passes in the following order:

1. **Basic** – main pass with parameters configured for filtering points not lying on the relief surface (surges). On this step the system rejects majority of points on buildings, and also correlators blunders (sharp spikes).

2. **Additional** – additional pass with parameters configured for searching surges, missed during basic step.

3. **Detailed** (off by default) – the pass with parameters configured for filtering points located on low objects, such as small buildings, cars, and so on.

After filtering the system may perform the following actions with points found (surges):

- rejecting surges from initial pickets layer;
- correction of surges found on initial pickets layer, that means editing of surges Z-co-ordinates;
- search for surges to analyse them with saving of found points to new vector layers without changing initial pickets layer.

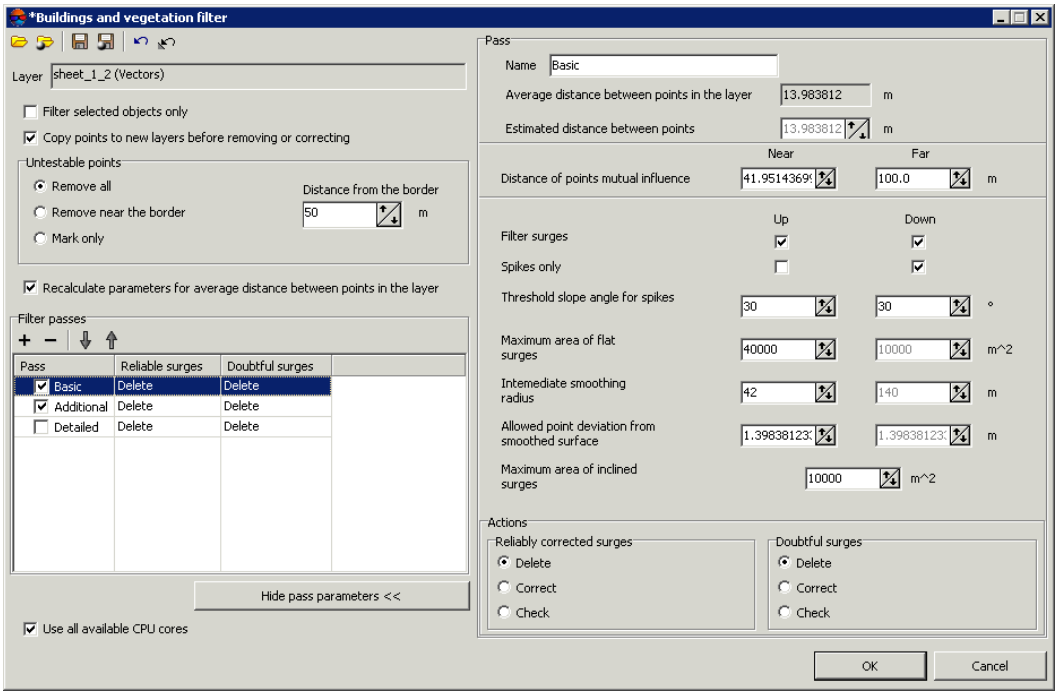


Fig. 53. Parameters of buildings and vegetation filter

The **Buildings and vegetation filter** window allows to specify filtering parameters and setup a number of filter passes. The **Layer** field displays a name of active vector layer. The window contains a standard toolbar.

buttons	Function
	allows to load a script of filter work from `*.x-filter` resource located out of active profile resources
	allows to load a script of filter work from `*.x-filter` resource located in active profile resources
	allows to save a current script of filter work to `*.x-filter` resource located out of active profile resources
	allows to save a current script of filter work to `*.x-filter` resource located in active profile resources
	allows to cancel all changes made to a script
	allows to go back to a standard script that includes two passes with default settings (regardless of which script has been loaded)

To filter objects on surface perform the following actions:

1. Make active a points layer.

   To avoid loss of data, it is recommended to use a copy of initial layer during filtering.

   To create a copy select **Vectors › Save as** and specify new name of pickets file.

   If a layer contains linear or area vector objects the filter may not work properly.

2. Select **Vectors › Filter › Buildings and vegetation filter**. The **Buildings and vegetation filter** window opens.

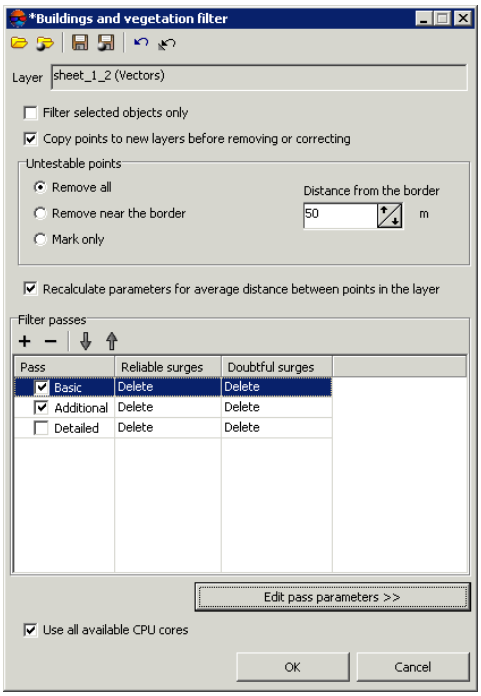


Fig. 54. Parameters of buildings and vegetation filter

3. [optional] In order to use filtering for selected objects (points group), set the **Filter selected objects only** checkbox on. Otherwise, filter is applied to all points of the layer.

   To filter a group of points, select it by mouse in 2D-window prior to start configuring the **buildings and vegetation filter**.

   When using filter for selected objects only, it is not recommended to set the **Remove near the border** option in the **Untestable points** section.

4. [optional] To increase the filtering operation performance set the **Copy points to new layers before removing or correcting** checkbox off. By default, the system saves removed or corrected pickets in new vector layers used for analysis of filtering results. These layers could be used to restore basic pickets layer (using operation of layers merging), if the copy of initial pickets layer was not created prior to filtering start.

   If the **Copy points to new layers before removing or correcting** checkbox is off, it is highly not recommended to apply filtering to initial pickets layer, since it is impossible to restore the initial layer after filtering.

5. In the **Untestable points** section specify one of the following actions with untestable pickets found after filtering:

Some points can be *untestable* – the points, in which vicinity there is not enough 'neighbour' points. For example, points located on the edge of the whole layer or in areas of low density of points (fields, forests, water bodies).

- **Remove all** – allows to remove all found untested pickets;
- **Remove near the border** – allows to set a value of distance in meters from the edge of the whole vector layer, at which all untestable pickets will be removed. The **Distance from the border** field is used to do this;
- **Mark only** – allows to save untested pickets to separate vector layer for further analysis.

6. [optional] The **Recalculate parameters for average distance between points in the layer** checkbox is set by default. After that the system calculates automatically values of average distance between pickets in active layer. This leads to automatic re-calculation of current parameters of each pass.

7. Specify a number of filter passes:

   - by default it is used two passes with standard parameters – **Basic** and **Additional**. Set off checkboxes to change set of passes.
   - the + button allows to add a new pass of filter;
   - the − button allows to remove selected pass of filter;
   - buttons and buttons allow to move selected pass up/down.

   The **Filter passes** section contains a table of passes and buttons used to change set of passes and their order with the following columns:

   - **Pass** – displays pass name and checkbox used to include a pass to script or to exclude it from filter workflow script;
   - **Reliable surges** – displays action to be applied to well-defined surges found, that are completely comply with specified filtering criteria;
   - **Doubtful surges** – displays action to be applied to ambiguous surges found, in which vicinity there is no data enough for analysis.

   It is necessary to select an action to be applied to reliable and doubtful surges during configuring of pass parameters.

8. Select a pass name and click the **Edit pass parameters> >** button. The **Pass** section is opened and allows to display and configure the following parameters of filter pass:

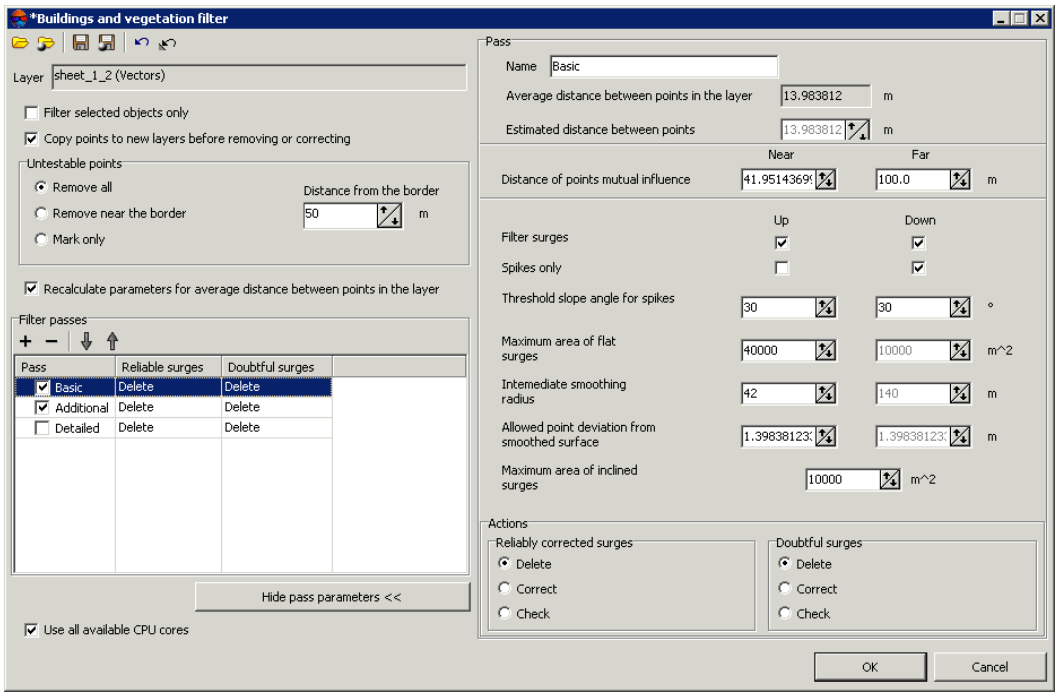


Fig. 55. Parameters of buildings and vegetation filter

- [optional] to change name of pass, input a new one in the **Name** field;
- the **Average distance between points in the layer** (in meters) and **Estimated distance between points** (in meters) after filtering are displayed in fields;
- specify **Near** and **Far distance of points mutual influence** in meters to define the circle radius. In this area points are checking for errors;

It is recommended to set the near distance (minimum circle radius) value as 3-5 values of **Average distance between points in the layer** parameter.

- specify the following filtering parameters **Up** (above surface) and/or **Down** (below surface):
  - **Filter surges** – allows to select pickets to be filtered: pickets on surface (high objects) and/or pickets below surface (pits);

For filter operating it is necessary to set at least one checkbox on.

  - **Spikes only** – is used to reject just sharp spikes above/below surface, that are defined by values of the **Threshold slope angle for spikes** and **Distance of points** parameters. The rest of parameters are not considered;

In an angle between three points exceeds in relation to selected measuring plane a value of the **Threshold slope angle for spikes** parameter, then the surge is called *spike*.

- **Threshold slope angle for spikes** – allows to specify angle of slope in relation to selected measuring plane (above and/or below surface) to define sharp spikes;

- **Maximum area of flat surges** – allows to define maximal area of plane surges (above/below surface) – points groups, that form smooth surfaces and are distant from some plane of neighbour points. Generally, the points are located on buildings roofs, and are lying on the same plane;

The filter is not applied to plane surface, which area exceeds the specified value.

- **Intermediate smoothing radius** – allows to specify a sphere radius (above/below surface), that defines a level of intermediate smoothing of surface;

- **Allowed point deviation from from smoothed surface** – allows to specify criterion, according which the filter is applied to all pickets with elevations that differ from smoothed surface more then on specified value;

- **Maximum area of flat surges** – allows to define maximal area of plane surges (above/below surface) – points groups, that form smooth surfaces and are distant from some plane of neighbour points.

The button allows to go back to a standard script that includes two passes with all default settings (regardless of which script has been loaded)

9. In the **Actions** section specify actions for reliable and doubtful surges found after any step of filtering:

   - **Delete** – deleting of pickets found from base pickets layer;
   - **Correct** – editing in base layer Z-coordinates of points found;
   - **Check** – saving of found pickets in a new layer without change of base layer.

   Reliable corrected surges – found well-defined surges that satisfy completely to all specified filtering criteria.

   Doubtful surges – ambiguous surges in which vicinity there is no data enough to analyse filtering operation possibility.

If the **Delete** or **Correct** option is selected, the system allows to edit base pickets layer.

In order to save deleted or corrected pickets to new layers it is recommended to set the **Copy points to new layers before removing or correcting** checkbox on.

If the **Check** option is selected the initial pickets layer remains unchanged, and found reliable or doubtful surges are copied to a new layer *Surges*.

10. [optional] To use all cores of workstation CPU for calculation operation, the **Use all available CPU cores** checkbox is set on in the system by default. It is necessary to set the checkbox off to use only one core.

11. Click OK. The system starts DEM filtering operation. When the filtering operation is completed the system displays information message about number of used basic points and filtered pickets.

There are the following recommendations concerning use of buildings and vegetation filter:

- it is recommended to use step-by-step filtering (in multiple passes with different parameter sets);
- the passes should be formed in ascending order of the following parameters: distances of mutual influence, radius of intermediate smoothing, and decreasing of allowed deviation of picket from smoothed surface;
- value of intermediate smoothing radius directly describes terrain relief features, that it why it is necessary to specify the radius value not exceeding 1500 meters;
- it is recommended to perform preliminary analysis of maximal area of flat surges on given territory (to measure it in a stereopair window) and then to compare it with area, calculated automatically for passes. If the measured area is bigger than calculated one, it is necessary to increase it;
- it is highly not recommended to specify a distance of mutual influence of pickets exceeding a step between pickets in more than 20 times, since it leads to considerable slowdown of filtering operation.

16.4. Building TIN

Perform the following actions to build TIN:

1. Choose the **TIN › Create** (**Ctrl+N, T**) or click the button of the **DEM** additional toolbar. The **Create TIN** window opens.

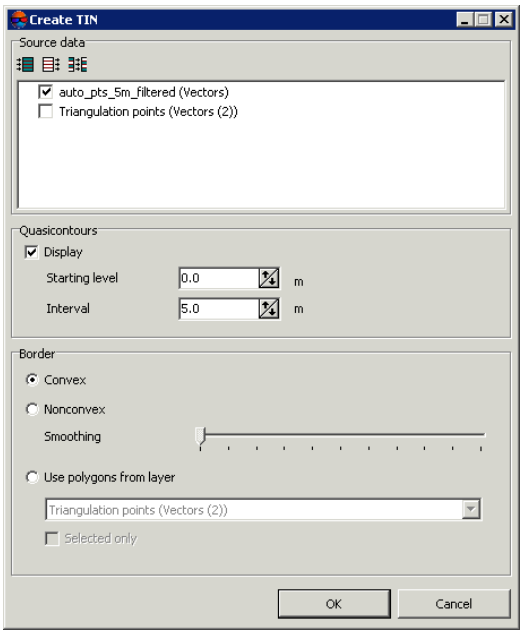


Fig. 56. The “Create TIN” window

2. [optional] By default in the **Source data** section set on checkboxes for all opened layers to use them in TIN creation. Set of checkboxes if there are open layers not for TIN.

   To select all available layers, click the button, to unselect all layers – click the button. To invert selecting layers it is used the button.

3. [optional] In the **Quasi-contours** section the **Display** checkbox on and in the **Starting level** filed specify minimal Z level (Zmin), from which to start quasi-contours creation.

4. [optional] Set the **Step** of quoasicontours in meters.

5. In the **Border** section set on the following:

   - **Convex** – the convex border of TIN is created;

     It is recommended to create convex border, when some part of vector objects does not cover all area of TIN creation (for example, when there are lakes and rivers on large scale images).

   - **Nonconvex** – the nonconvex border of TIN is created;

     It is recommended to place the **Smoothing** slider in the middle and smoothly move it to the left to get the best results.

- **Use polygons from layer** – to create a TIN with convex border in limits of area of polygon(s) selected in the layers list. Select from the list the layer with polygons, which is used as a border. In order to define a border of TIN creation area, just from selected polygons, set the **Selected only** checkbox on.

6. Click OK. The TIN is created in the new *TIN* layer.

16.5. DEM creation by TIN

Program includes capability of creating DEM by triangulated irregular network (TIN) Perform the following actions to do this:

1. Create or load the source TIN.

2. Choose **DEM › Build DEM › From TIN** (**Ctrl+N, D**). The **DEM by TIN creation parameters** window opens.

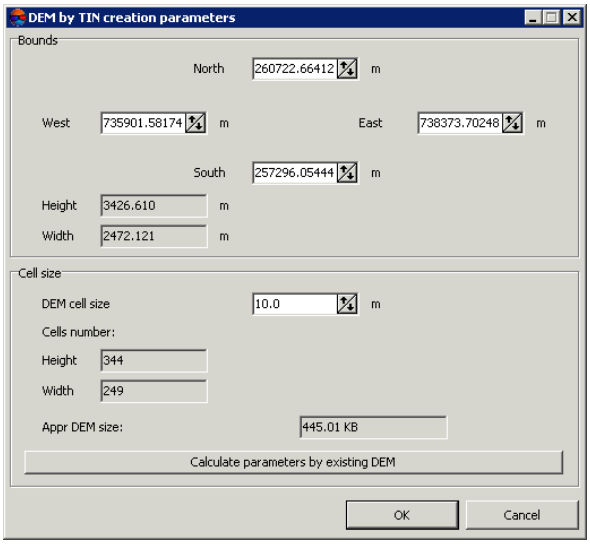


Fig. 57. DEM by TIN creation parameters

3. Specify the borders of DEM in the **North**, **West**, **East** and **South** fields. Calculated size of DEM displays in the **Height** and **Width** fields (in meters).

Default values are coordinates of rectangle corners, which generate TIN creation area.

4. In the **Cell size** specify the **DEM cell size** in meters to define cell size of output DEM. The **Cells number**, calculated considering specified cell size, displays in the **Height** and **Width** fields. Also the **Approximately DEM size** in megabytes displays in the appropriate field.

DEM cell size should be comparable to average distance between points of base TIN layer. If less cell size is used, the time of DEM creation and size of output file increase, but accuracy is not.

5. [optional] It is possible to use parameters of existed DEM to calculate parameters of output DEM. To do that, click the **Calculate parameters by existing DEM** button and choose DEM file in active profile resources.

6. Click OK. Define DEM file name and folder in active profile resources and click **Save**. The system starts DEM building operation.

   The new layer is created in the *layer manager*.

While moving marker on DEM, XYZ-coordinates of DEM cells displays in 2D-window status bar.

If base TIN layer was changed it is possible to rebuild DEM. The **DEM › Rebuild by TIN** menu item is used for that.

See the detailed information about other was of creation, edit, filter and accuracy control of DEM in the “DTM creation” User Manual.

16.6. Further project processing

Further project processing includes the following steps:

- stereo vectorization – see detailed description of self-calibration operation in the “Vectorization” User Manual;
- orthorectification – See detailed description of self-calibration operation in the “Orthorectification” User Manual;
- the mosaic creation with sheets splitting – detailed description of self-calibration operation in the “GeoMosaic” User Manual;
- etc.